# THE TECH ENGINEERING NEWS

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**IN THIS ISSUE . . .**

**Biology and Biological Engineering**

**Sulphur and War**

**What You Eat Is Our Business**

**Guayule Grows Up**

**Moly, Workhorse Of the Oil Field**

*Information supplied by an Industrial Publication*

There are two operational factors that have more to do with the life and efficiency of reamers than may be generally known. One is the matter of feeds and speeds; the other, the condition of the hole.

As to the former—with due regard to machine set-up, required finish, and part design—in general, reamer speeds should be from 60 to 70% of drilling speeds, and feeds should be two to three times faster.

The amount of stock left in the hole has considerable effect on reamer life. If there is insufficient stock, the reamer will tend to bind instead of cutting. This is also true with bell mouthed holes, caused by faulty drilling, or drilling without a guide bushing.

For efficient reaming in ferrous metals 1/64 inch of stock should be left on holes up to 1/2 inch diameter, and 1/32 inch left in holes of greater diameter. A smaller amount of stock may be left in softer metals. The correct amount in individual cases can be determined by experiment.

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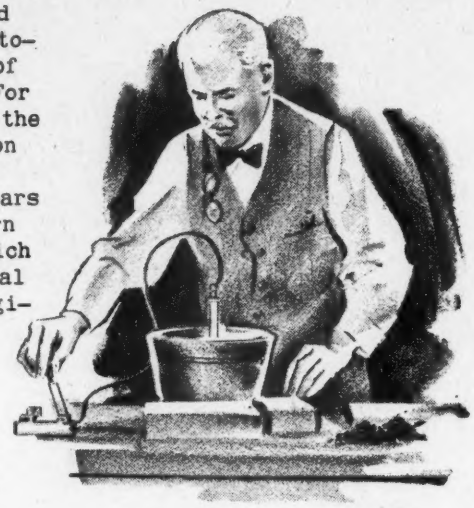
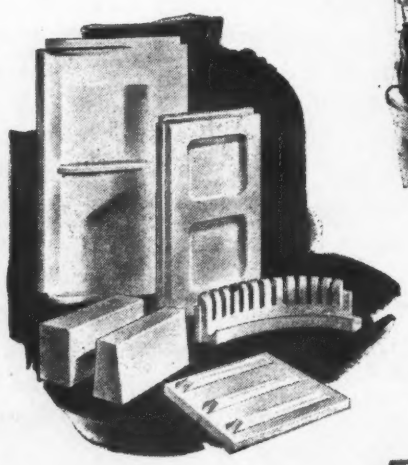


2) For instance, one of these super refractories is vitally important to the process by which our huge naval and coast defense guns are annealed under closely controlled conditions.

3) To withstand other specific service needs covering a wide range of conditions over 65 varieties of Carborundum Brand Specialized Refractories are available. Used in furnaces, kilns, retorts and refining equipment, they are helping to speed output of thousands of war essentials.



4) After the war, these super refractories will help produce new and better materials. When you encounter a refractory problem in the field, remember Carborundum Refractory Specialists stand ready to help you solve it. The Carborundum Company, Perth Amboy, New Jersey.

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## IDEAS TRANSLATED INTO STEEL

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It is a pity that more of them were not built before the war, for they are made of ideas as well as steel. Ideas that help railroads carry more people more comfortably; that bring greater safety and more dependable performance; that make coach travel easy and luxurious by day and by night. Ideas that make possible faster schedules, and yield substantial operating economies.

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It is not too much to say, in view of their present dominant position, that it will be a world of Timken Tapered Roller Bearings; for there is no bearing requirement that Timken Bearings cannot meet.

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# THE TECH ENGINEERING NEWS

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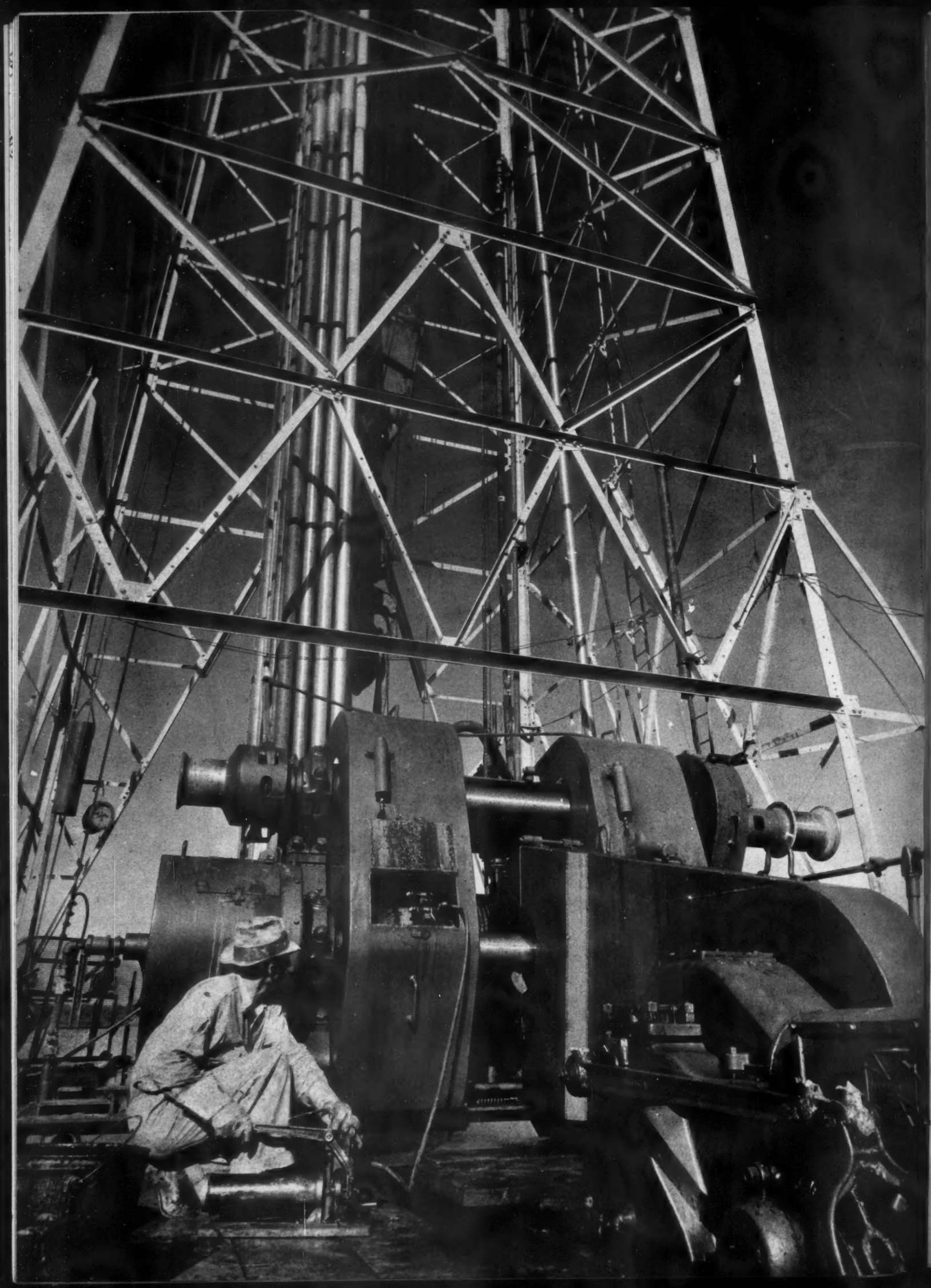


# THIS IS M. I. T.

# BIOLOGY AND BIOLOGICAL ENGINEERING

BY THE DEPARTMENT

*M. I. T. Photos*

THE impact of the advances in the fields of physics and chemistry on the general field of biology has been so great that in many of the specialized fields the boundaries between biology, physics and chemistry have practically disappeared. This is especially true for the biochemist who is concerned with the structure of organic molecules like the proteins, carbohydrates and other naturally occurring substances; the colloid chemist who attempts to understand the colloidal properties of protoplasm; the biophysicist and chemical physicist who investigate the structure of biological materials; and the modern physiologist who uses electronic devices in almost every experimental technique. In all cases there has been an attempt to introduce the quantitative method to biological science.

Only a few generations ago the training of the biologist was chiefly in descriptive science. Physics and chemistry were included more as mental disciplines and as an integral part of philosophy than as important working tools. In the latter half of the nineteenth century the importance of the physical and chemical approach to biology was recognized by a few, but it was not until about twenty-five years ago that this view was shared by more than a small fraction of professional biologists. As a result of great research advances made possible by the quantitative approach, the trend in biology was altered, in a manner perhaps as important as that caused by the publication of "The Origin of the Species" which, in its time, turned practically all biological interest to studies in organic evolution.

One result of this changing emphasis is the revision of the type of training necessary to equip students with the knowledge of mathematics, physics and chemistry which will permit them to take an active part in developing these fertile new fields of Quantitative Biology, or in more specialized cases, Physical Biology or Biophysics. Such a new curriculum has been developed in the Department of Biology and Biological Engineering at the Institute, where men are trained for teaching and research in the various branches of the biological sciences, for study and research in medicine and for work in the field of applied biology or biological engineering. The curriculum in Physical Biology is the most comprehensive and comprises five years of study leading to the S.B. and S.M. degrees which are conferred simultaneously. Included are five years of biological studies, five years of chemistry, four years of physics and two of mathematics. These courses are supplemented by studies in the humanities and by an original investigation during the fifth year. A sufficient number of elective courses are allowed in the fourth and fifth years to permit a certain amount of specialization.

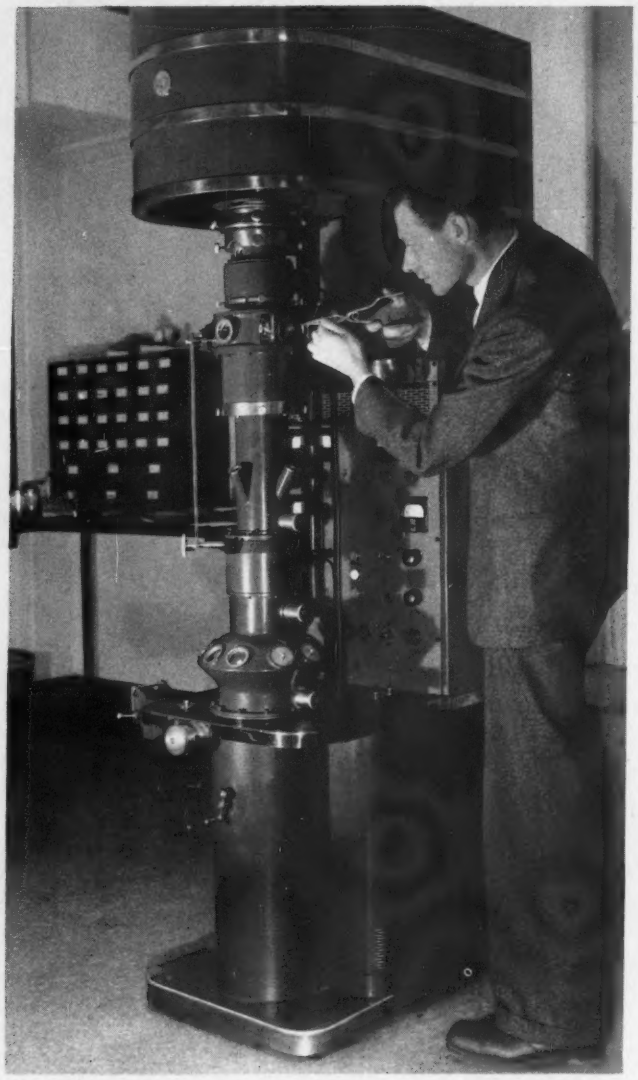
The courses of study have been integrated so as to give simultaneous training in chemistry, physics, mathematics and biology. This plan makes it possible to train students to recognize the problems, to select the techniques best suited for their successful solution (or to develop such techniques if they are not available) and to interpret the significance of the findings. Without such integrated training we would be training either biologists veneered with chemistry and physics or chemists or physicists veneered with biology.

Perhaps as good a way as any to illustrate the scope of Quantitative Biology is to mention some of the fields of study and interest in our own laboratories at the Institute: spectroscopy (ultraviolet to infra-red), X-ray diffraction, polarized light microscopy, electron microscopy, surface film techniques, colloid phenomena, cathode ray oscillography in the study of bioelectric phenomena, short wave techniques, ultrasonics, and instrumentation. To these can be added numerous special techniques in biochemistry, bacteriology, general physiology, nutrition and enzymology.

In the evolution of chemistry technological developments and industrial applications soon led to the establishment of a profession of Chemical Engineering. In physics there were similar outgrowths in the applied field, including Electrical and Mechanical Engineering. At the Institute the corresponding outgrowth in biology has been termed Biological Engineering. The biological industries, such as those concerned with canning, processing and preserving of foodstuffs; fermentation industries, including those concerned with the preparation of solvents and liquors; plant products for non-edible purposes such as used in the rubber, starch, oils and plastics industries; leather and tanning, glue and gelatin; development of drugs, pharmaceuticals, vitamins and hormones; the development of new therapeutic, surgical and diagnostic devices, including ultra-

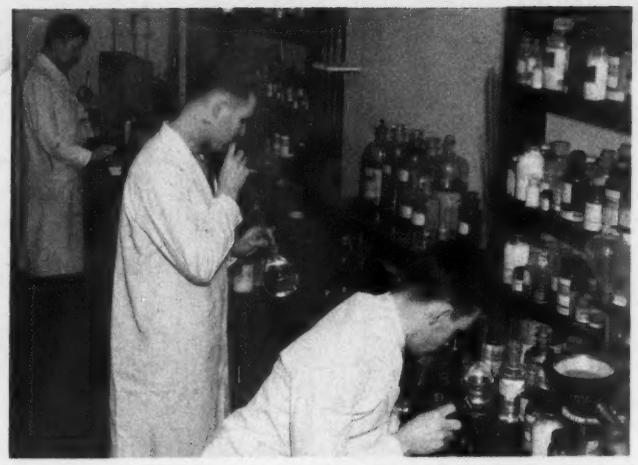
violet light, X-rays and diathermy, are approaching the point where, as in the electrical and chemical industries, extensive and widespread research programs of a developmental nature are being initiated and the multiplicity of little specialties is being integrated into a new entity of biological engineering.

For the most productive work in this field the Department of Biology and Biological Engineering has devised a curriculum which lays stress on the broad application of the scientific and engineering methods to biological problems, particularly in applied fields in



*One of the electron microscopes in the Department of Biology and Biological Engineering used in investigating the molecular architecture of natural materials.*

the industries. This training integrated with a sound and intensive training in biology, chemistry and physics and supplemented with work in chemical and electrical engineering should provide an ideal training for the wide variety of industrial demands. That such demands can be and are met is illustrated by the results of the specialized training in Food Technology which for a number of years has contributed a large number of "biological engineers" who now fill many of the key positions in a wide variety of food industries. These men have brought to the food industries a thorough training in the basic sciences pertaining to foods, combined with the ability to apply the knowledge in the technical processes of food production, manufac-



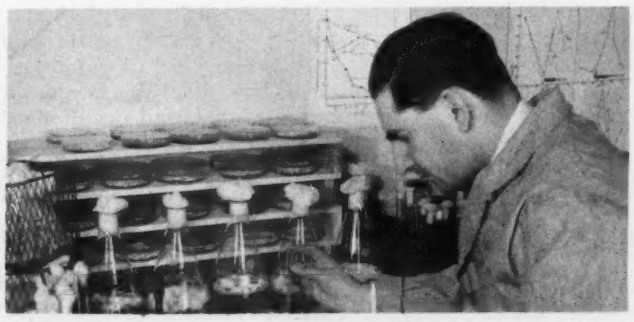
*Microscopic, chemical and nutritional investigation of foods by students and research assistants.*

ture, storage and distribution, as well as quality control through a knowledge of chemical, physical, biological and microscopic techniques. There is little question that the less specialized and more intensive general training in Biological Engineering will prove equally successful in satisfying the demands of the biological industries for biological engineers.

Medicine can perhaps be considered one of the most promising fields of Biological Engineering. Its practitioners and researchers are constantly "trouble shooting." The strides that this field of human engineering has taken result from its ready acceptance of the modern quantitative method applied by the physiologist, chemist, physicist and bacteriologist. Medicine demands not only skill in the art of healing, but also a training well founded in the basic sciences upon which it can build its own peculiar art. It is not only the potential medical researcher but the general practitioner as well who must have this essential basic foundation, just as the biologist in other applied fields must supplement skill in the art with knowledge of the underlying sciences.

This theme of integration of the physical and chemical with the biological sciences underlies the multitude of activities of the Department of Biology and Biological Engineering. Not only is this true in the undergraduate and graduate training programs of study, but it is logically carried through to the various research programs that are under way in its laboratories.

The war has dislocated many of the departmental plans for student training and has diverted research activities to problems important to the war effort. However, this experience has been valuable in many respects, not the least of which is the demonstration of the versatility of Biological Engineering and the many opportunities which await its further developments.



*Penicillin production being investigated in the microbiological chemistry laboratories.*

# SULPHUR AND WAR

By D. B. MASON, '23

Technical Director, Freeport Sulphur Company

*Pictures courtesy Freeport Sulphur Company*
*Robert Yarnell Richie Photos*

SULPHUR, which enters either as element or in its various compounds, into all the technologies of Peace, is vital for War. Indeed, the war uses of sulphur appear in the earliest history of mankind. There is reason to believe that the ancient Greeks threw molten volcanic brimstone as well as lead, at warriors scaling the walls of besieged cities. Alexander the Great is said to have abandoned his "Drang nach Osten" upon hearing that a tribe living on the banks of the Ganges defended the cities with a mixture of "lightning" shot from the walls. It is even contended that Moses handed down a recipe for a gun-powder explosive to Joshua and Gideon. Certainly the ancient Chinese had developed the art of fireworks, probably based on sulphur.

The "sulphurous smoke of battle," sung by mediaeval poets, must refer to the crude gunpowder mixture of 30 parts sulphur, 60 parts nitre, and charcoal, which the alchemist-monk Berthold Schwartz was the first to concoct when he invented cannon-fire in 1328, although in England in 1270 Roger Bacon gave directions for mixing "English powder" of similar composition. We know how this newer weapon changed the wars of chivalry to more bitter contests and eventually thus ousted feudalism. Georgius Agricola (1555) wrote "Sulphur is made to enter into that powder — execrable invention! — which hurls iron, brass or stone instruments of war of a new kind." However, it is interesting to note that pryotechnic displays used to celebrate a peace were made of this same mixture.

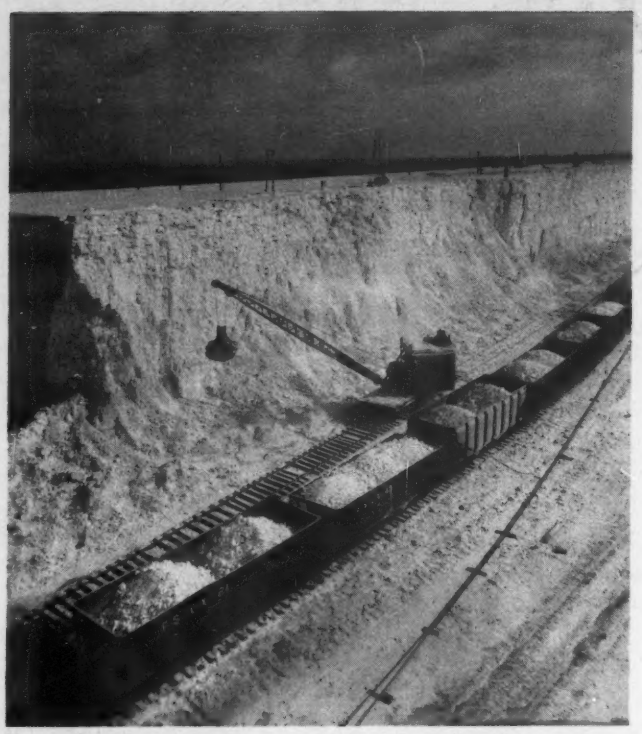
This gunpowder of the Middle Ages got its first rival in the eighteenth century when military brown powder began to be scientifically compounded. Sulphur content decreased to 20%, and cellulose began to be used instead of charcoal. In 1786 the science of explosives was founded by Berthollet, who studied detonation of potassium chlorate with carbon and found it enhanced by small amounts of sulphur.

From the time of Berthold Schwartz to Berthollet the sulphur content of explosives decreased from 30 per cent to 10 per cent and a great variety of explosive powders was developed. Today these old gunpowder compositions with 10–18 per cent sulphur are used as blasting agents in coal mining and for sporting shotguns. When in 1845 Schonbein nitrated cotton with a mixture of nitric and sulphuric acids, he discovered guncotton and ushered in the era of high-power explosives.

About 75 per cent of all forms of sulphur is used as acid, and modern warfare is absolutely dependent on sulphuric acid. Just as consumption of sulphuric acid is a measure of industrial activity in times of peace, even more so is a nation's capacity to produce sulphuric acid a gauge of its ability to wage war, for there is no explosive (except black powder) which does not depend on sulphuric acid in some stage of manufacture.

Germany, before World War I, had ample capacity for sulphuric acid ready to be immediately diverted to

*The beginning of a new sulphur vat. The pipe arrangement in the foreground is distributing molten sulphur. Sulphur from the completed vat in the background is being loaded on railroad cars for shipment.*



*One of the mountainous stock piles of sulphur, from which freight cars are being loaded preparatory to being shipped to a seaport.*

explosives manufacture. Sulphur and sodium sulphate had been stockpiled at Hamburg, ostensibly for the glass industry. Sulphuric acid was being made in 1912 by 98 plants, four-fifths of whose production was used domestically by the fertilizer industry, and one-fifth or 300,000 tons was being used by the extensive dye industry, indigo and aniline alone taking 108,661 tons in 1913. Lacking sources of brimstone, Germany used pyrites and metallurgical by-product gas for acid production and had well-developed processes for recovery of sulphur from coke oven gases and gypsum. Thus in 1914, when her exports of oleum to other countries were stopped, Germany had ample acid supplies for diversified explosives production. The importance of acid production in a war economy has been emphasized recently by reports of successful and extensive bombing of German facilities at Leverkusen and other chemical industry centers.

Before the last World War, England made only about one million tons of acid yearly and had only three small plants for making high strength acid. Most oleum was imported from Germany, and it was only after one and one-half years of war, when every possible plant was diverted to manufacture of sulphuric acid by the Department of Munitions, that England's explosives industry came alive. By 1918, 11,000 tons of acid weekly, or two and one-half million tons yearly, — double the pre-war capacity — were being produced by 42 firms in 115 plants. Today, with an adult chemical industry, England is self-sufficient as to sulphuric acid supplies.

Brimstone production by the Frasch process began in the United States in 1903, and the swing from Sicilian brimstone to pyrites, which started in the nineties, was nearly complete. At this time the sulphuric acid and explosives industry was entirely inadequate for national defense purposes, 23 states being without sulphuric acid plants. In addition to The Union Sulphur Company, which began production in 1903, a second company, the Freeport Sulphur Company, operating the Frasch process, began production in 1912. By the beginning of World War I in 1914, a considerable acid industry had been built up, particularly in the South where fertilizer for the cotton fields offered a market. Over 95 per cent of the acid was still made from pyrites or from waste gases from zinc and copper smelters. By 1917, when war production had greatly increased the demand for acid, and submarine interference with Spanish pyrites shipments became serious, it became obvious that the supply of sulphur and acid would need careful attention.

As the war went on, the supply of pyrites and of acid from zinc and copper ores proved to be disappointingly low and it became necessary for the War Industries Board to assume control of allocation of sulphur materials. This was the first complete control of any chemical material made necessary by war-caused shortage.

In 1915 total production of sulphuric acid in the United States amounted to 2,500,000 tons of 100 per cent acid. By the time of our entry into the war production had climbed to 4,800,000 tons per year, but total requirements for both military and civilian needs were estimated in 1917 at 5,600,000 tons. Neither acid plants nor raw materials were available for such production. Acid plants formerly consuming pyrites were converted to brimstone, with an increased productive capacity in some cases as high as 400 per cent, due to the higher gas strength and more intensive operation made possible with brimstone. The government built contact acid plants totaling 560 tons daily capacity. Sulphur producers drilled more wells, expanded plants, and produced as never before. By November 1, 1918, production reached 6,000,000 tons per year and the report of the Sulphur and Pyrites Section of the War Industries Board ended with these sentences, "At the signing of the Armistice, the sulphur situation was very easy; the output from the two producing properties was adequate for all present and anticipated requirements. Stocks at the mines had been replenished to about a million tons total, and there was a large stock at the acid plants."

The great expansion of brimstone use in acid production during the war stimulated technical advance in both process and design of acid plants. Brimstone's high purity and freedom from catalyst poisons permitted great simplification of plant design, reduction of labor and fixed charges and efficient recovery of waste heat.

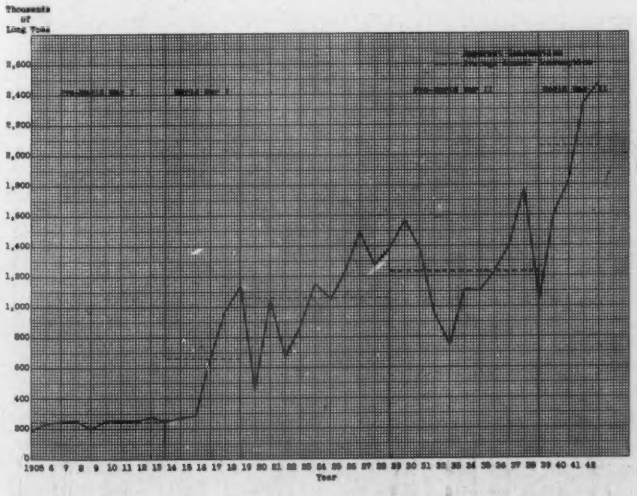
***Sulphur wells in operation. The derricks resemble those of an oil field and are used to drill wells down to the sulphur formation, which may be as deep as 2,000 feet below the surface.***

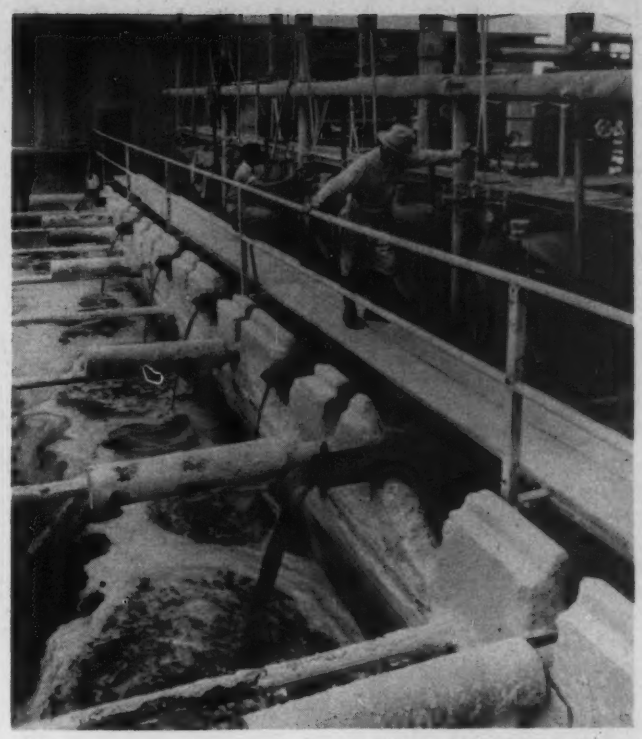
These advantages have raised brimstone's participation in the acid industry from three per cent in 1914 to 48 per cent in 1920, and more than 70 per cent at the present time. During the same period the per cent of acid made in contact plants has risen from about 20 per cent to more than 50 per cent.

It is interesting to contrast the World War I situation of the United States as to sulphur with the present supply of this necessary raw material. Of all the vitally strategic materials, sulphur is the only one not placed under priority allocation. Indeed, the supply of sulphur at all times has been so adequate that the War Production Board has urged sulphur users to stock up so that sulphur shipments can be decreased during periods of transportation congestion. Stocks at the sulphur mines of the four sulphur producing companies have been maintained since this war began at about 4,000,000 tons or one and a half times the highest annual United States consumption. The attached chart shows the apparent consumption of native sulphur (brimstone) by years from 1904 to 1942. The abrupt rise in sulphur consumption (change from pyrites to brimstone) in the first World War and the peace-time rise in consumption since then are particularly noticeable.

In World War I, when nitric acid was being made from Chilean nitrate, spent sulphuric acid from nitration of cotton and toluene was consumed in production of nitric acid. In the present war, almost all of the nitric acid is produced by fixation of atmospheric nitrogen and subsequent catalytic oxidation, which requires no sulphuric acid. Improvements, both in nitration procedures and in acid recovery processes, permit the re-use of much of the sulphuric acid used in nitration processes. An outstanding achievement of the chemical industry has been the organization of concentration and use of spent acids from munitions plants. In this war sulphuric acid can thus be used four or five times more effectively in explosives production than in the last war. On the other hand, aerial warfare has vastly expanded the requirements, and the demand for acid continues to increase as the problem of reëstablishing agriculture and food supply throughout the world confronts the farmers and fertilizer manufacturers of this country. It has been estimated that 11 million tons of fertilizer per annum, instead of the previous peak of 8 million tons, will be required over the next several years. Thus, sulphur and its principal product, sulphuric acid, will turn at once from munitions to food when the war on the Axis is won and the war on famine begins in earnest. The production which has won the Army-Navy "E" award for the plants of both large producers will be continued in the interests of peace and plenty.

*Apparent domestic consumption of native sulphur, 1904–1942.* (*Long tons*)



*Photograph by Robert Yarnall Richie*

***Molten sulphur collecting vat at the relay station of the Grande Ecaille sulphur mine of Freeport Sulphur Company. Sulphur is here collected from the individual wells for metering and pumping to the vat.***

So much for the use of sulphur in manufacturing the actual munitions of war, where, as concentrated sulphuric acid, acting chiefly as dehydrating agent, it expedites nitration of cellulose into guncotton and toluol into T.N.T. and picric acid. Elemental sulphur also serves in various ways in fuses, booster charges and in military pyrotechnic devices where its low ignition temperature helps to insure accurate firing. But modern warfare utilizes a great deal more than explosives. Mustard gas and dichloro diethyl sulphide were weapons appearing in the last World War made by bubbling ethylene through sulphur chloride or calcium sulphide. Sulphur chloride is also indirectly used in making one of the constituents of "Lewisite" while constituents for phosgene are dried over sulphuric acid before use. In another war gas, methyl sulfonyl chloride, the organic sulphur compound acts as irritant and vesicant.

The civilian uses of sulphur are varied and indirect and in most articles of commerce sulphur is employed in the manufacture at some stage. In war, also, sulphur can be said to enter into practically all products used by our fighting men. It has been estimated that, of every $100 spent on the war program, $97 goes for expenditures using sulphur in some stage of manufacture.

Taking a carrier-based torpedo plane as an example, let us trace the role that sulphur has played in equipping and maintaining the ship, the plane, and the crew. First, the heavy steel armor plate of the carrier underwent pickling with sulphuric acid to be freed of oxide

(*Continued on page 164*)

# WHAT YOU EAT IS OUR BUSINESS

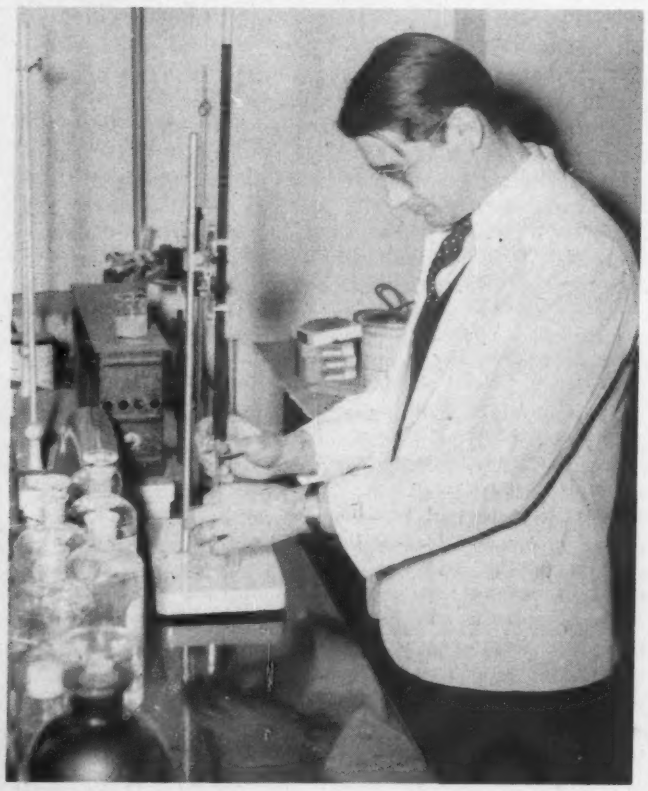
By ERNEST E. LOCKHART, Ph.D.

Research Associate

Nutritional Biochemistry Laboratories, M. I. T.

"ALL the world's a stage" and the character all of us mortals play ceaselessly, one that Shakespeare neglected to mention, is that of the machine. The story of this machine, which most of us take for granted and the proper functioning of which enables us to play our other characters badly or well, has been in recent years the basis of much discussion, popular as well as scientific, and social as well as political. This machine, of course, is our body. Because it operates on a twenty-four hour schedule, our machine requires stoking occasionally; for some of us once or twice a day, but for most of us, even now during war times and rationing, "three squares" have retained their traditional popularity. It is our business of the moment to talk about a few of the machines here at M. I. T. and their interest in other machines particularly from the point of view of fuel engineers.

*Dr. Lockhart performing a calcium titration*



Good diets are to the nutritional biochemist what high octane gas is to a fuel engineer, and just as the latter has had to make a study of many individual components of numerous petroleum products, so has the former had to study the individual components of various food products. And just as it was essential for M. I. T. to have laboratories for the development of better fuels, so was it perhaps inevitable that the Institute should have as a part of its Department of Biology and Biological Engineering, laboratories for the development of better diets. These laboratories, under the direction of Professor Robert S. Harris, are now engaged by the problems of applied nutrition. Rapidly new facts concerning diets as we know them today are being accumulated, and possibilities for making them better diets sought after, investigated and tested. Although we can assume that the fuel engineer is by no means at the end of his trail, we can state quite emphatically that the nutritional engineer is only at the beginning. In this country much basic material has already become a part of the scientific and popular background. Other countries are not so fortunate, and in most only sparse and unrelated daubings have been applied to the new canvas. However, let us be trite and say that accomplishment always has its small beginning. In the case of applied nutrition, our accomplishments will, we hope, lead to better and more efficient living through better diets, not only in this country but in others as well.

Let us go back to examine briefly the foundation from which the larger structure of more healthful living will derive its strength.

For many years food chemists here and elsewhere have been studying foods primarily with respect to the amounts and kinds of protein, fat, sugar and minerals they contain, because these materials contributed not only to the structure but also to the functioning of the body. In this country we have recorded these essential data for many natural foods. We have some knowledge of what happens to these food components when natural foods are prepared for public use by food

*Dr. Tapia and Dr. Segura feeding a special food preparation to one of the white rats*

industries and, further, the changes that take place when foods, both natural and processed, are prepared for the table. The story does not end here.

A few years ago, as science reckons time, the vitamins were discovered. These important chemical compounds are, as is well known, accessories or catalysts without which the food we eat would be of little value to us. About ten or twelve of these vital components are now known and others, no doubt, will be added to the list. The discovery of vitamins necessitated the reëxamination of all of the foods that had been analyzed earlier for the other food components. It also necessitated a more careful study of losses incurred during the transit of foods to processing industries and kitchens as well as during their storage and cooking. The knowledge that some of the vitamins are extremely unstable and are destroyed when exposed to oxygen or processed with heat or chemicals has led to changes in procedures both in industry and in the kitchen. However, much remains still to be done before the food we eat reaches us in its most nutritious condition.

Medical science has contributed its great share to the newer knowledge of nutrition by recognizing a number of pathological conditions resulting from a lack of good protein, carbohydrate, fat, minerals or vitamins. Most clinical pictures result from a simultaneous deficiency of several essential factors. Only rarely do the attributes of a disease indicate the deficiency of a single factor. From the data accumulated largely by medical men, it has been possible for the Food and Nutrition Board of the National Research Council to estimate how much of each major nutritional component, mineral and vitamin is required to maintain human beings of all ages in a state of normal nutrition.

Nutritional biochemists, such as we have in our Nutritional Biochemistry Laboratories, make use of the data accumulated by food chemists and the medical profession to aid in the solution of their problems. Where essential data may be lacking, they use known techniques or develop new ones to acquire the necessary information. All of the information, knowledge and methods of research of food chemists and medical men are employed by nutritional biochemists as tools in their daily work.

What are some of the problems which vex applied nutritionists at the present time? Due to current conditions these problems comprise those related to the nutrition of men in the armed forces, industrial workers manufacturing materials of war, others of the home front, and populations in occupied and allied countries. Our laboratories have been and are being faced with problems pertaining to all these groups. Some of these problems cannot be dealt with individually inasmuch as many aspects of one may have an immediate bearing upon or application to some of the others. This may best be illustrated by several examples.

Several years ago we were called upon by the United States Antarctic Service to aid in the development of a concentrated ration to be used in the field by sledging parties. An ideal ration to be used by men planning to be away from their base of operations for several months should have the following characteristics. It should be palatable in order that the men might first of all eat it. A ration prepared according to the best scientific standards with respect to protein, carbohydrate, fat, minerals, vitamin and energy content would be a failure if it were inedible. Consequently, it had to be as tasty as possible. It must also be stable under many different conditions, such as tropical sun and polar cold. It must contain a certain variety of foods so that it could be eaten day after day without becoming psychologically monotonous. It must not require too much time for its preparation, and must be edible, at least in part, if no preparation at all is possible. Finally, it must be nutritious and contain an abundance of energy. After several months of research and experimentation it was found possible to meet all of these requirements, at least adequately. Since the proof of the pudding is the eating thereof, we may say that this article might never have been written had the ration failed in the field. The author lived on it alone for two and a half months. This problem of applied nutrition is mentioned because, although somewhat unusual at the time it was encountered, the United States Army with its troops living under an infinite variety of conditions in all corners of the globe was faced with a very similar problem at the outset of the war. The information and experience passed on have without doubt contributed something to the solution of its problem.

A second example may serve to indicate the value nutritional research may have in industry. The National Research Council Committee on Nutrition in Industry, of which Professor Harris is a member, has realized that the nutrition of industrial workers, particularly now when the tempo of production has increased many fold and rationing is a part of daily living, must be made as excellent as possible. Toward this end plant cafeterias and restaurants are being set up and supervised by specially trained dietitians, nutritious mid-shift lunches are being served, and, so far as is practicable, simple instruction in good nutrition is being made available. In addition, several research groups, ours among them, are studying the value of vitamin supplements with respect to absenteeism due to ill health and to increasing efficiency and morale as indicated by greater and better production. At the present time we are carrying on such a test with a selected group of employees in a large eastern industrial plant. These workers were divided into several

(*Continued on page 166*)

# GUAYULE GROWS UP

By RUSSELL K. DOSTAL, 2–46
Advertising Manager, The Tech Engineering News

*Pictures courtesy the United States Forest Service*

EDITOR'S NOTE: *"Guayule Grows Up" is the successor to an article, "Rubber from Weeds," T. E. N., March 1942, by Alan Michaels, '44. While Mr. Michaels described the planting and cultivation of the shrub, Mr. Dostal has attempted to show the most recent methods of production.*

TREMENDOUS strides have been made by the rubber industry since the first bewildering days after Pearl Harbor. In the brief span of two years, the grave rubber shortage that faced the nation has been relieved. The rubber companies and research workers have done the impossible by developing new and improved synthetic rubbers. To them much of the credit for solving the rubber problem has rightfully gone.

Synthetic rubber, however, is not the whole solution to the problem. In many cases synthetic rubber is as good or even better than the natural product, but in other instances, such as in truck tires, inner tubes and bus casings, natural rubber is required.

When our supplies from the Far East were cut off by the war with Japan, we searched for new supplies of natural rubber. Unfortunately, the plantations of South America were not ready to supply more than a trickle of the rubber needed.

These conditions caused the Government to intensify investigations into rubber-bearing plants adapted to culture in this country and to begin production of the most promising of them.

There are many plants that grow in North America which are capable of yielding rubber. Outstanding among them is the guayule shrub (pronounced gwa-yoo-lee).

***Guayule shrub is first chopped into chips and the chips then ground through three sets of corrugated rollers such as these. Each succeeding set of rollers grinds the mass finer.***

The guayule, except for a higher content in resins, yields the same type rubber as that produced by the East Indies tree, Hevea.

The guayule looks much like the sage brush and grows wild in Northern Mexico and adjacent areas. The plant is two to three feet in height and easily recognized by the gray-green appearance of the leaves or the many yellow flowers on the stems.

Unlike the Hevea, where the rubber is contained in a fluid that can be drawn off by tapping the tree, the guayule deposits the pure rubber in a layer of cells under the bark. The shrub produces the greatest amount of rubber in a wet season followed by a long dry period. It is during the dry period that the plant actually begins the work of depositing the rubber. The rubber content of a two- to three-year old plant, raised under optimum conditions, varies from 18 to 22 per cent of the dry weight of the plant.

Guayule was first noted in 1852 by a physician of the Mexican Boundary Survey. It was not until 1904, however, that large scale production began. At this time several processing plants were built in Mexico and Texas. Two decades later, in 1925, plantations for continued experimentation and commercial production were begun in the Salinas Valley of California.

Because of the low world price of rubber, the companies interested in buayule did not invest the sums necessary for expansion. By a law passed in March, 1942, the government assumed all production of guayule and all experimentation connected with it. Of interest is the new Department of Agriculture Appropriation Bill which came up before Congress in December, 1943. The House of Representatives cut in half the amount desired by the Department for enlarging the guayule plantations and maintaining the present projects. The action of the House in this matter is an excellent example of the nation's assumption that the rubber crisis is over. Should circumstances later emphasize the desirability of continuing production of guayule, a year would be lost for lack of planting supplies.

The guayule shrub reproduces by seeds, and seed collection is of primary importance. New tractor-drawn collector machines, built especially for guayule, now pick the seed from the rows of plants.

Unfortunately, the guayule seed does not germinate readily and so it must be treated before planting. The seed is allowed to soak in water for twenty-four hours, after which it is washed in a one-half to one and one-half per cent calcium hypochlorite bath. The seeds are then rewashed, dried, and packed in airtight containers.

The seeds are planted by an ingenious machine, sowing six or seven rows at a time. The seed is covered by a fine layer of white sand to keep it in place, and is watered frequently until the plants are up and have struck root. Hereafter, the watering is less frequent. All irrigation is done by the rather expensive overhead irrigation system, for it was thought that surface irri-

*A guayule nursery in the Salinas Valley, California Seedlings are approximately three months old*

gation was not practicable for the guayule. Recent progress points to a revision of this procedure.

Once the plants have become established they grow rapidly and in five months are ready for transplanting to the fields. After removal from the beds, the plants are packed in boxes and shipped to the fields.

The planting machines are capable of planting several rows at a time. Workers on the planter feed plants into moving clips, which plant the small shrubs in the earth. Packing wheels firm the soil about the roots.

The shrubs are meticulously cared for over a period of two to three years, during which time they reach their maturity as far as the rubber content is concerned. When this point has been reached, the shrubs are harvested and dried in the hot sun.

The actual process of separating the rubber from the shrub requires the complete destruction of the plant. The process of extraction is a relatively simple process that involves no use of chemistry but rather is accomplished by mechanical means. A description of the process as outlined on the floor plan of a typical guayule mill (pages 152–153) will be given in detail.

The guayule is transported to the mill where it is stored for several days after which time it is chopped up. The chopped bush goes into a receiving bin where it is again stored, but this time for a much shorter period.

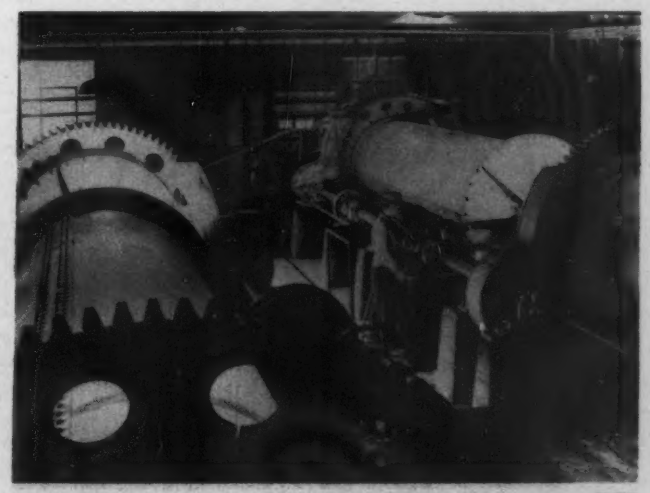
The chopped shrub is fed onto a conveyor that carries the material to the intake chute of a rotary dryer. The plant passes from one end of the dryer by means of a large suction fan at the discharge end. Steam-heated air passes over the shrub as it travels from one end of the dryer to the other. This process lowers the moisture content from 20 to 14 per cent.

The dried chips move to a conveyor belt which carried them over a magnetic pulley to remove any pieces of iron that might be present. The belt delivers the shrub to the first crusher, consisting of corrugated rolls and a cracker roll to break up pieces of root. The crusher rolls have a one-eighth inch opening. The shrub moves through the No. 2 and No. 3 crushers, which are set for .010″ and .006″ clearances respectively.

The crushed shrub is conveyed to the first of four pebble mills. These mills are five by twenty-two feet in size and rotate at 30 r.p.m. Water, in the ratio of 4.5 pounds of water to one pound of shrub, is added to facilitate milling. The chopped shrub passes through each of the four pebble mills. These mills are filled to about 50 per cent of their volume with small flint pebbles to grind the shrub. At the discharge end of the fourth mill, an additional amount of water is added to the mixture.

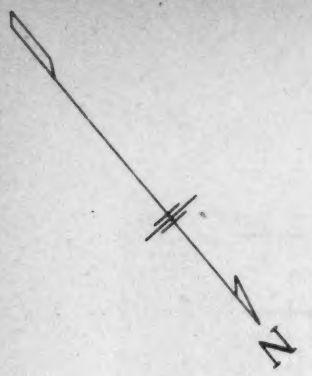
The slurry is lifted by a centrifugal pump into a 17,000 gallon tank for the first phase in the separation of

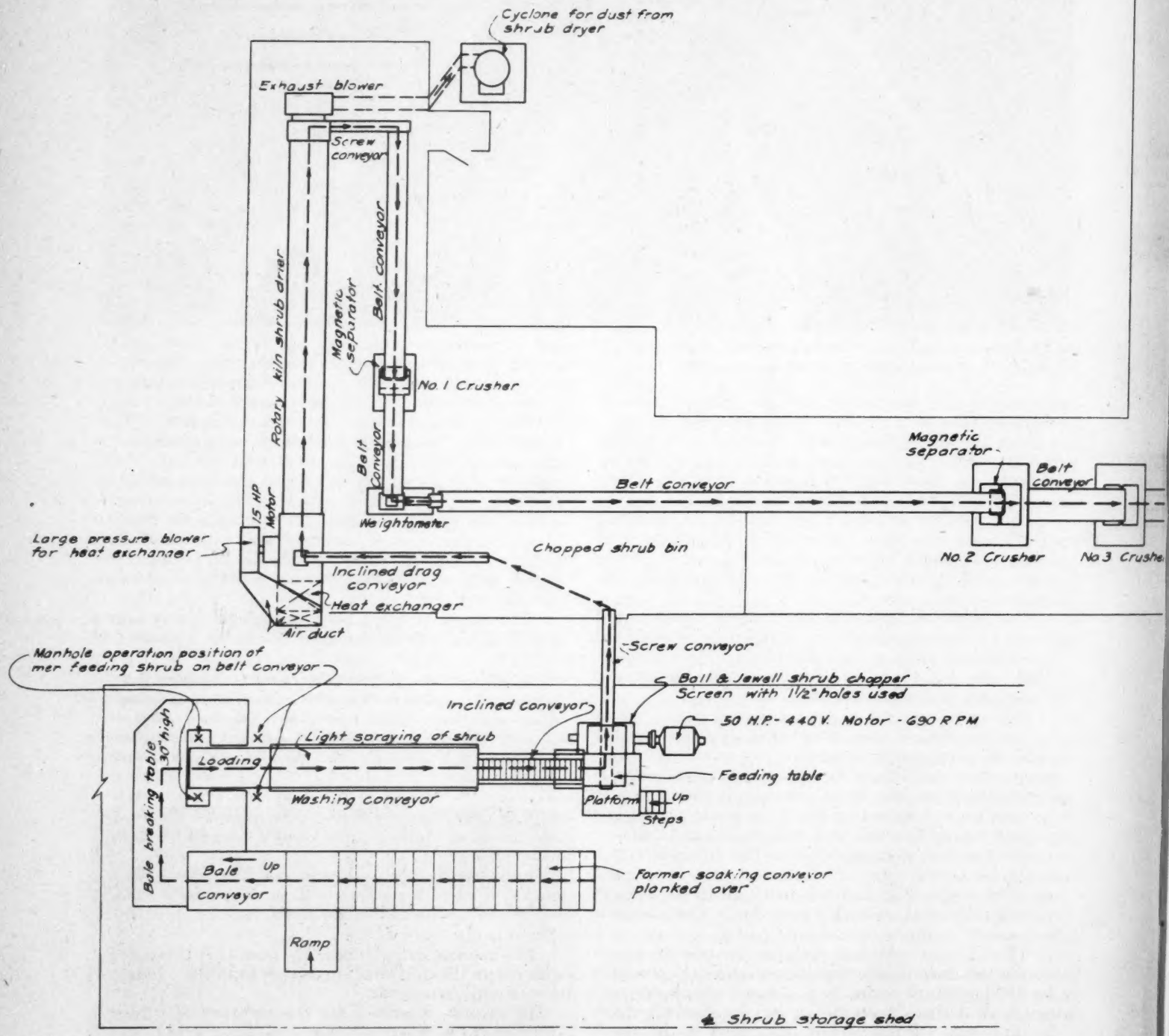
*After grinding the guayule shrub, water is added and the whole macerated in pebble mills. These rotating tubes are lined with hard bricks and about one-third filled with smooth pebbles. The mass is ground between the pebbles and lining and the rubber particles freed from the plant fibers.*



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
EMERGENCY RUBBER PROJECT
EVAN W. KELLEY, DIRECTOR

# FLOOR PLAN FLOW DIAGRAM FOR SPENCE FACTORY SALINAS, CALIF.

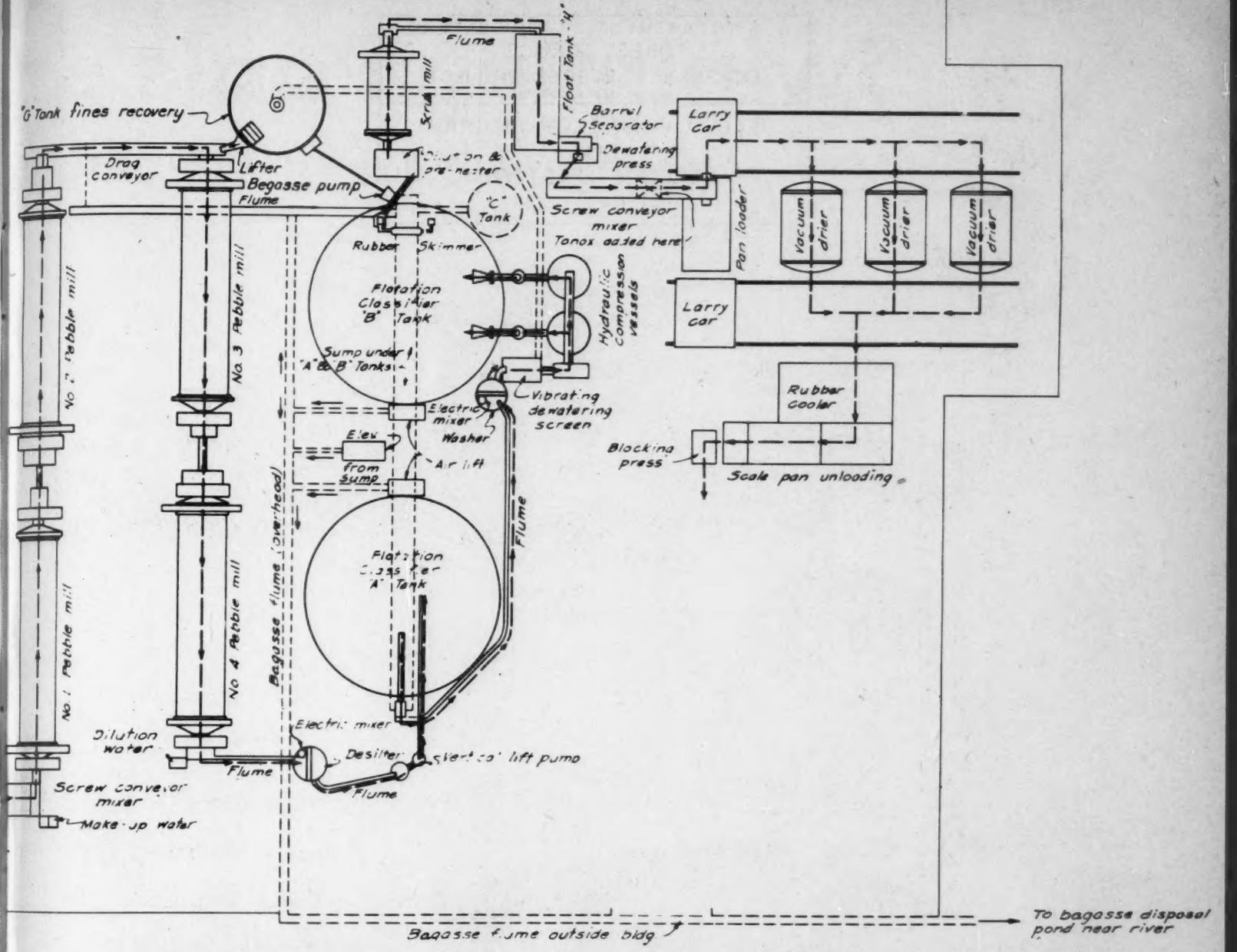



SCALE IN FEET

LEGEND

Flow of Guayule Shrub and Rubber through Factory




the rubber by flotation. The rubber, which has agglomerated into small worms, rises to the surface of the tank while the water-soaked woody particles sink to the bottom. The worms are skimmed off for further processing and the fiber drawn from the tank.

From the tank labeled, "flotation classifier 'A' tank," as shown on the floor plan, the rubber moves on a vibrating screen that removes up to 40 per cent of the water present. This water, which contains some particles of rubber, is returned to the No. 3 pebble mill for reprocessing.

Approximately two and one-half gallons of clean water per minute mixes with the worms. The worms contain small amounts of cork and this cork must be removed. The worms are elevated to one of two 935 gallon pressure vessels which are alternately placed under 250 pounds of hydraulic pressure. This pressure causes the water to absorb the air that is present in the cork. The rubber is discharged into tank B where the water-soaked cork sinks and the rubber is skimmed off. The rubber worms pass through another smaller pebble mill with the addition of more fresh water. The action of the mill is to free any adhering cork from the rubber.

The washed rubber is skimmed off and passed into a revolving cylinder of fine perforated screening. The rubber works its way through the openings and into buckets provided to catch the rubber. Water is pressed from the rubber and the product conveyed to shallow drying pans. The worms are spread evenly in layers of one inch depth on the pans. When a score of these pans have been filled, the contents are mechanically shoveled into a vacuum dryer. The dryer is subjected to 22 inches of steam pressure and a 28-inch vacuum for four hours.

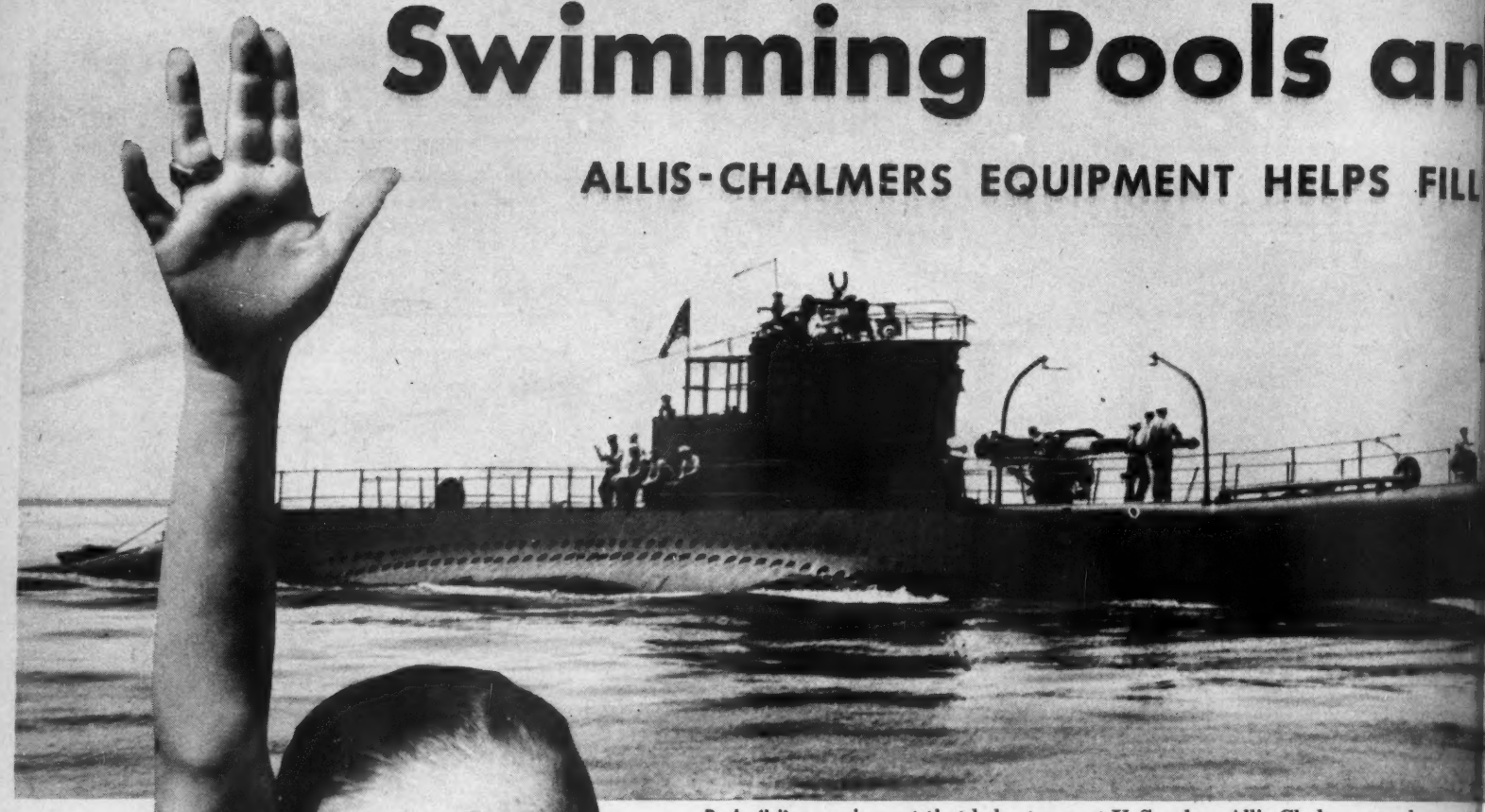
The rubber emerges in a crepe mat. Several of these are pressed into 100-pound blocks by hydraulic presses. Two blocks are packed in a wooden box for shipment to the manufacturer.

The complete process from the time that harvested shrub enters the mill until it emerges from the vacuum dryer requires nine hours.

The process described for the recovery of rubber from guayule is practically the same process that was developed at the beginning of the industry in Mexico, over forty years ago. Of course, it has been refined over the years, but nevertheless the process remains expensive. The process extracts resins with the rubber, and the presence of the resins prevent a wider use of the guayule rubber. (*Continued on page 168*)

# Swimming Pools an

## ALLIS-CHALMERS EQUIPMENT HELPS FILL O



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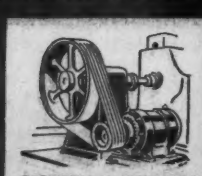

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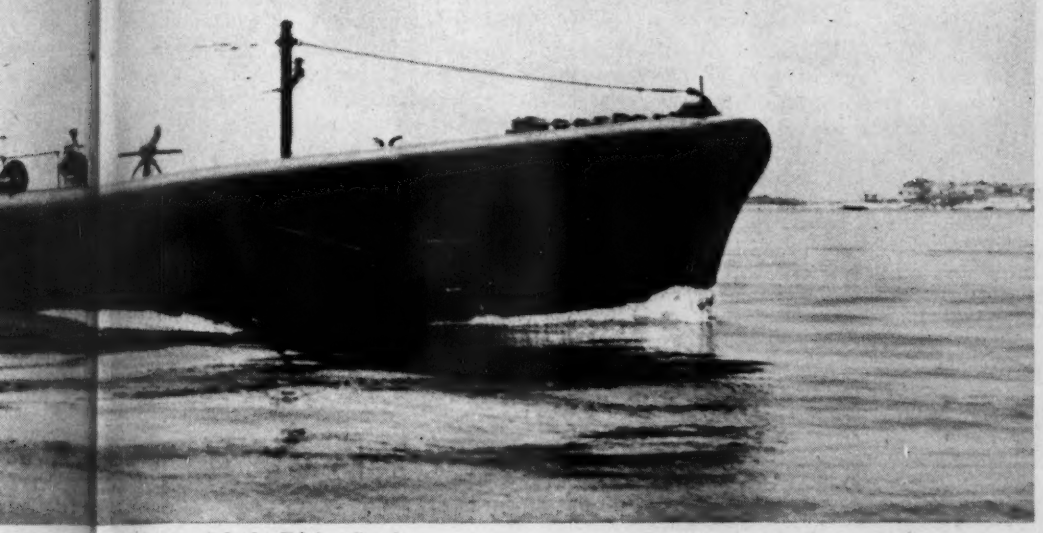

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Every one of the thousands of Allis-Chalmers men and women is working *all out* for Victory—and every one is gaining production experience which will be invaluable to the Nation in the Peacetime rebuilding program which must follow!

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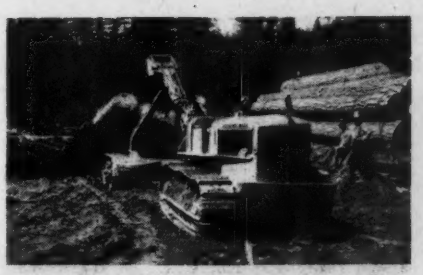

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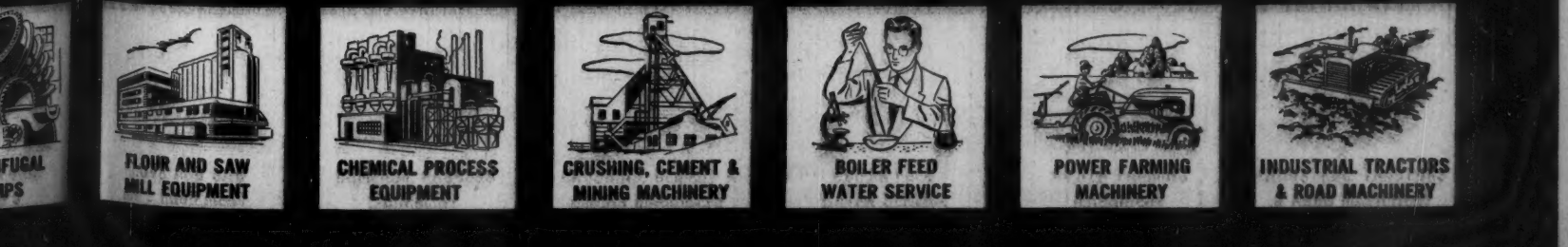
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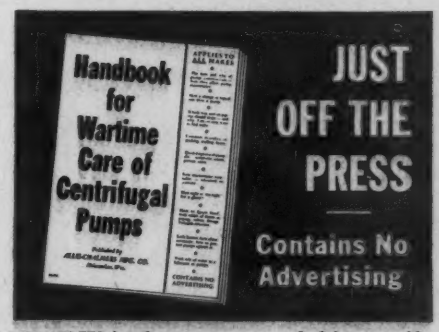
# VICTORY NEWS

**Converted Carriers Aid Navy!** Official Navy Photos reveal that merchant vessels are rapidly being converted into auxiliary-aircraft escort ships to protect convoys from subs and bombers. On some ships already converted a great variety of A-C equipment has been installed—including main propulsion turbines, auxiliary generating sets, condensers, centrifugal pumps, motors and control.

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**New "Electro-Cooler"!** Vitally needed increases in power transformer capacities can now be obtained quickly with a new system of forced-oil cooling that saves 25% in critical war materials on new transformers.

This new Allis-Chalmers cooling unit, called the "Electro-Cooler," will step up capacity of transformers already in service by about 20 to 60%.

This new unit makes the forced-oil system of cooling transformers highly practical because it is built compact, factory-assembled and factory-tested at high pressure to minimize the possibility of future maintenance. If transformer has radiator valves, the unit can be removed without draining transformer oil and parts can be replaced without delay in transformer operation.

**FOR VICTORY**
**Buy United States War Bonds**

# MOLY, WORKHORSE OF THE OIL FIELD

By ARTHUR LINZ, JR., 2–46

*Pictures courtesy Climax Molybdenum Company*
*Robert Yarnell Richie Photos*

PROBABLY no other metal has had such a confusing metallurgical history through the ages as molybdenum. Although the element obtained its name from the Greek word μόλνβδος, this term literally means lead-like, and has been bandied back and forth since the days of Pliny, being used in reference to various lead compounds, and even graphite. Even as late as 1557, one Salvedensis in his treatise on metals, "De Re Metallica," states that, "Plumbago, galena, molybdena, are one and the same thing." In fact, it was not until a couple of centuries later that Mr. A. F. Cronstedt, in his "Systems of Mineralogy," published in 1758, first pointed out that there was a difference between molybdena and plumbago, or black lead. This marked the beginning of the chemistry of molybdenum. In 1778 the eminent Swedish chemist, Carl Wilhelm Scheele, published an essay announcing the discovery of a new element, which he called molybdaena, and in 1790 the French Academy published a letter from M. Gadolin, a noted Finnish chemist, to M. Berthollet which describes Hielm's isolation of pure metallic molybdenum for the first time.

*Typical deep drilling oil field. The derrick in the foreground is a rotary drilling rig showing travelling block assembly in position.*

However, these were merely signposts along the way. Between the years 1818 and 1825 Prof. J. J. Berzelius by a series of experiments established the foundation for the chemistry of molybdenum, although almost a hundred years were to pass before the element was used as anything but a chemical reagent. The earliest serious research on the subject of molybdenum steels seems to have been around 1894, when chromium-tungsten steel was improved by the addition of molybdenum. By 1904 molybdenum tool steel was an established product, but despite this the history of molybdenum steels in this country was more one of continuous investigation, rather than practical use, up to 1918. This was due mainly to the high cost and uncertain production of the metal. The discovery and development of the world's largest molybdenum mine at Climax, Colorado, largely eliminated these two factors, and World War I brought a slight boom to the production of the metal. Although the end of the war left molybdenum without a market, this was only temporary, and by the end of 1924, production started to grow by leaps and bounds, a process which has continued almost without a break ever since. Annual world consumption has increased from about 200,000 pounds in 1912 to over 60,000,000 pounds in 1943.

The reasons for this phenomenal climb in production may be easily demonstrated by showing the versatility and usefulness of molybdenum steels in a vital industry.

Our transportation system, and indeed our whole war machine, is absolutely dependent on oil as fuel for

the internal combustion engine. And no one knows better than the men who are producing oil today what alloy steels mean to oil production. Even if they have not made present deep drilling possible, they have certainly made it practical.

Many types of molybdenum steels, both wrought and cast, are extensively used in drilling and pumping equipment. Figure 1 is a detailed drawing of a rotary drilling rig, the kind most extensively used for deep drilling in the United States. Those parts which are labeled are made of some kind of molybdenum steel. However, there are many groups of molybdenum steels containing varying percentages of other alloying materials. Since there is such a considerable variety of alloy steels from which to choose, an effective basis for selection must be set up. Naturally cost plays some part in this selection, but the major point has to be the ability of the steel to meet the physical requirements.

There are two ways of determining the ability of the steel to meet the physical requirements. The first is by service tests. That is, by making a part from the steel in question, actually putting the part in service, and keeping a record of its performance. This method is the most effective, but it is not always the most practical, as breakdowns in a drilling rig are apt to be both expensive and dangerous. Where no service records exist, the safest basis for selection are the physical properties of a steel, as determined by laboratory tests. All that is necessary is to apply the results of the tests to the requirements. That is, given a knowledge of the loads to be met, and the likelihood of wear, or abrasion, and an understanding of what the physical properties, as usually reported, really mean, it is a simple matter to establish the practical relation between requirements and properties.

Tensile strength is one of the physical properties of a steel that is most often emphasized. Literally, it is a measure of the steel's resistance to being pulled apart or "broken in tension." The practical value of this property may seem limited, because there are not very many applications on a drilling rig where the loads are purely tension. But tensile strength has a decided influence on other properties that directly affect the performance of many parts. The fatigue, torsional, and shear strength of steel are generally related to tensile strength. So tensile strength alone can often be taken as a measure of the ability of a steel to perform in parts subject to fatigue, such as draw works, crown block and travelling block shafts, tool joints, sucker rods, or any case where loads are repeated or alternating. The same holds true with parts subject to torsional loads, such as tool joints, drill pipe, fish-tail bits, or rotary pinion shafts.

The yield point of a steel can be taken as a measure of its elasticity. It represents the maximum load that can be imposed without causing injurious permanent deformation in the steel. Usually the yield point follows the tensile strength very closely; in most heat treated alloy steels it is from 75 to 85 per cent of the tensile strength. This is known as the yield-tensile ratio, and its value from the practical standpoint is the indication it gives of a high safety factor. That is, a steel which can be loaded nearer the limit set by tensile strength without being damaged, is a safer steel.

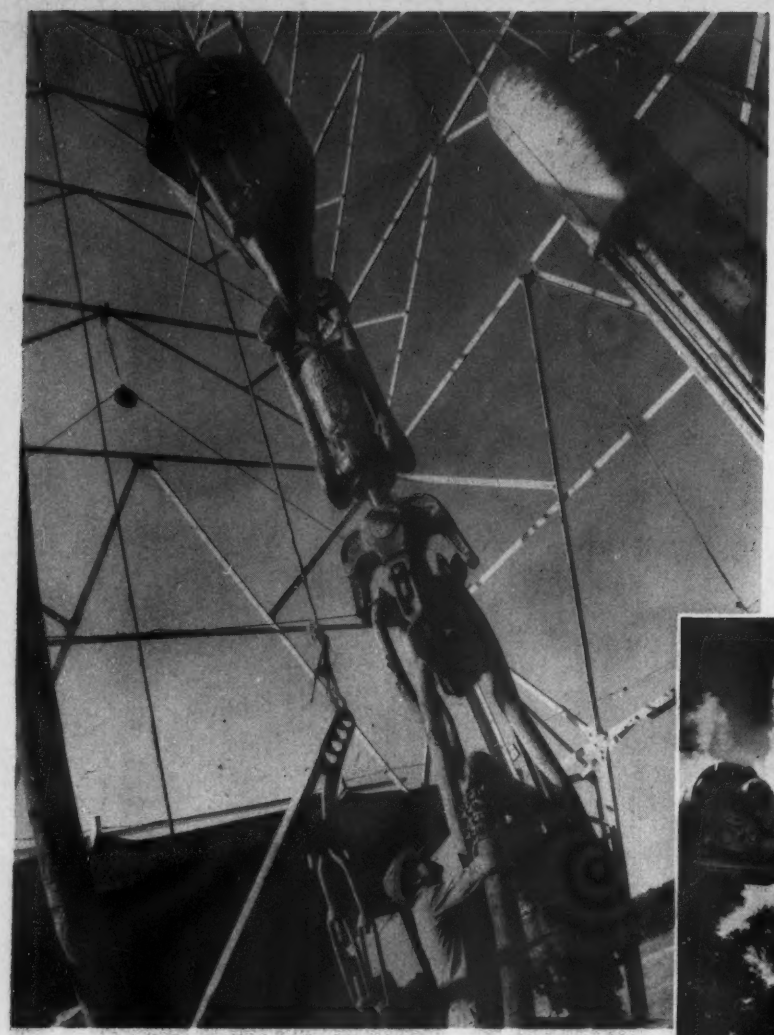
Ductility in its strictest sense means the ability of a steel to stand permanent deformation, such as bending or stretching, without breaking. It is indicated by reporting the results of the tensile tests by the percentage of elongation and reduction of area. When a specimen is pulled apart in a tensile testing machine, two phenomena take place. The steel sample stretches

*Walking beam pumping rig, with power plant in the background*

before it breaks, and tends to constrict, or "neck down," at the point of fracture. The amount of stretch is the elongation, and the ratio of the diameter at the point of fracture to the original diameter, reported as percentage, is reduction of area.

However, there is still another phase of ductility that is worth considering. A ductile steel usually has good impact strength, because resistance to an impact implies a certain degree of plasticity, or toughness. Impact strength is just what the term implies: ability to take a sudden heavy blow without breaking. The impact test is not only valuable as a measure of toughness but also as a means of determining whether or not the steel is susceptible to temper brittleness. This characteristic is present in some steels after slow cooling from drawing temperatures in the range between 800 to 1000° F. It makes its presence known in service by the sudden, and often costly, failure of a part under an impact load that it should ordinarily carry without difficulty.

Hardness is also a very important property in steel. It is usually defined as resistance to permanent deformation, because most hardness tests consist of indenting the steel by one means or another and calibrating the dent. From the practical standpoint high hardness implies good resistance to gouging, wear, abrasion, or erosion, but it is so throroughly involved with tensile and impact properties that it should always be considered with respect to them. It varies directly with the tensile strength, and usually indirectly with the impact strength and ductility. Therefore, in any given case, it is a question whether hardness should be sacrificed for toughness and ductility, or the two latter properties



*Heavy duty travelling block, hook, and swivel for guiding turning drill pipe. Hook is made of chromium-molybdenum cast steel*

sacrificed for hardness and strength. The answer is usually determined by the physical requirements of the application.

The most practical steel for drilling purposes is the one that lends itself to the most effective compromise. That is, steel that can be treated to relatively high, uniform hardness, and still be tough. Such a steel would be resistant to galling, gouging, and general battering, but still be tough enough to carry the sudden loads and strains met in drilling service. It is here that molybdenum steels enter into the picture. As it is obviously impossible to discuss all the different molybdenum steels used in the oil industry, the following discussion will be confined to the general properties

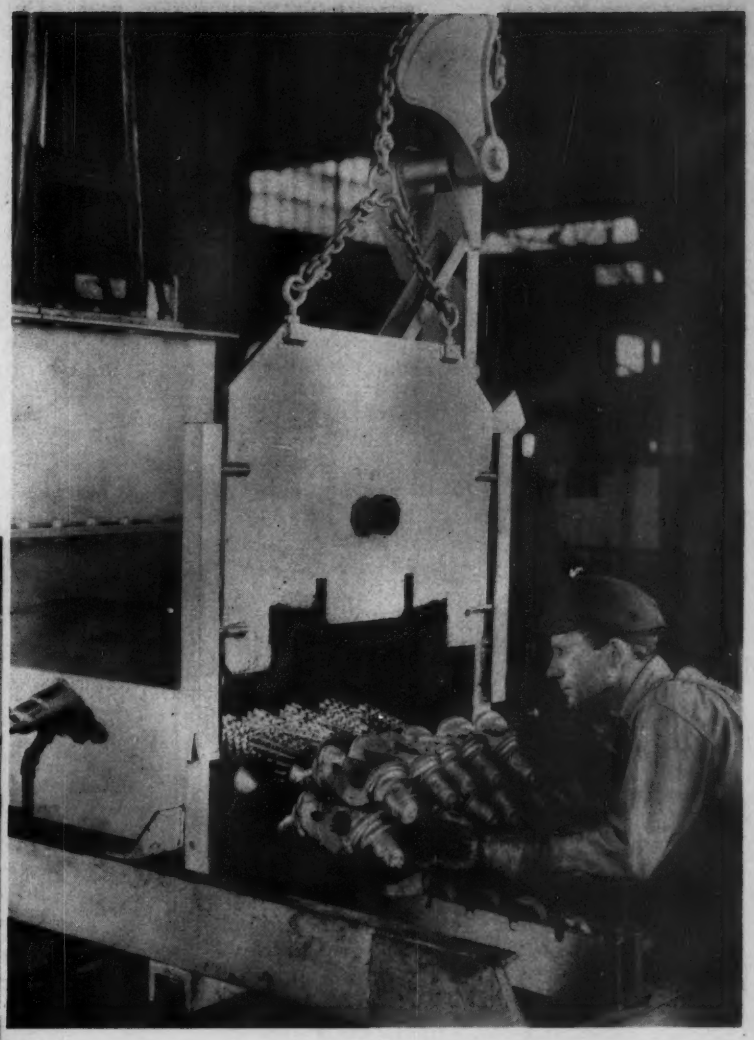
*Christmas tree valve. Body of this complicated control valve is made of manganese-molybdenum cast steel*

that the addition of molybdenum gives to various groups of steels.

In general, the beneficial effects of molybdenum in steel arise from the influence the element has on transformations which occur in ferrous alloys, rather than from any cleaning or deoxidizing action. In other words, the improved physical properties obtainable through the addition of molybdenum to steel are a result of its alloying effects rather than any role the element plays during the steel making process.

*Moly steel cutters (heat-treated)*

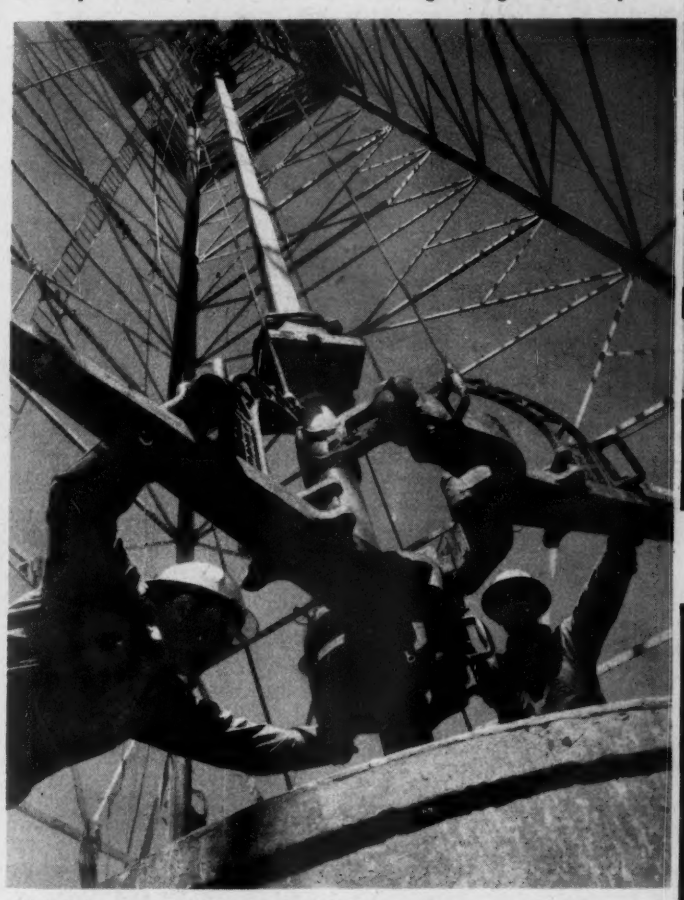
*Heat treating nickel-molybdenum steel parts for roller bit cutters for oil field service. These bits are used for cutting through rock formations and other material too hard for drag bits.*



Molybdenum is usually added to steel in one of three forms:

1. as calcium molybdate containing 40 to 50 per cent molybdenum;
2. as ferromolybdenum containing 50 to 65 per cent molybdenum;
3. as molybdenum oxide in briquette form or canned.

Molybdenum is soluble in iron and does not oxidize readily in the molten bath, assuring a high recovery.



*Molybdenum steel tongs making up pipe*

Since the metal has a lower affinity for oxygen than does iron, the oxides of molybdenum in the molten bath are easily dissociated and reduced, allowing the molybdenum to dissolve in the metal.

The ferromolybdenum may be dissolved directly in the steel. No slag reactions are involved.

When added to steel, molybdenum, like several other elements, imparts strength to the alloy. At the same time it has demonstrated a greater ability than any other alloying element to withstand high continu-

(*Continued on page 170*)

*Fish-tail bits for drilling through soft formations. These are made of Silicon-Molybdenum steel, treated so that they are readily weldable and especially suitable where hard facing is required.*

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## A TECH MAN'S PARADISE

The R.A.F., the R.C.A.F., and the A.A.F. are the best agents that the M. I. T. Alumni Placement Bureau and the Alumni Placement Bureaus of hundreds of colleges all over the country could ever have. They are carrying out a service which is more thorough than any engineer's employment office could ever hope to equal. They are creating jobs for Tech men at the source. Through their systematic and total bombing of European industry they are not only making new positions for Tech men to fill, they are arranging for new factories for Tech men to build, industries for Tech men to reëstablish, and even are destroying stock piles of raw material sources which Tech men will have to replace and rediscover. If we are to believe news reports, they are obliterating a whole continent which Tech men will have to level off and then reconstruct.

When engineers worry about their position in the postwar world, they are really being shortsighted. An Allied victory taken for granted, the job facing us is next to stupendous in magnitude. For, even excluding the development of areas not directly affected by conflicting forces (areas such as North and South America), every branch of the engineering profession will have its niche in the rehabilitation of industry and manufacturing.

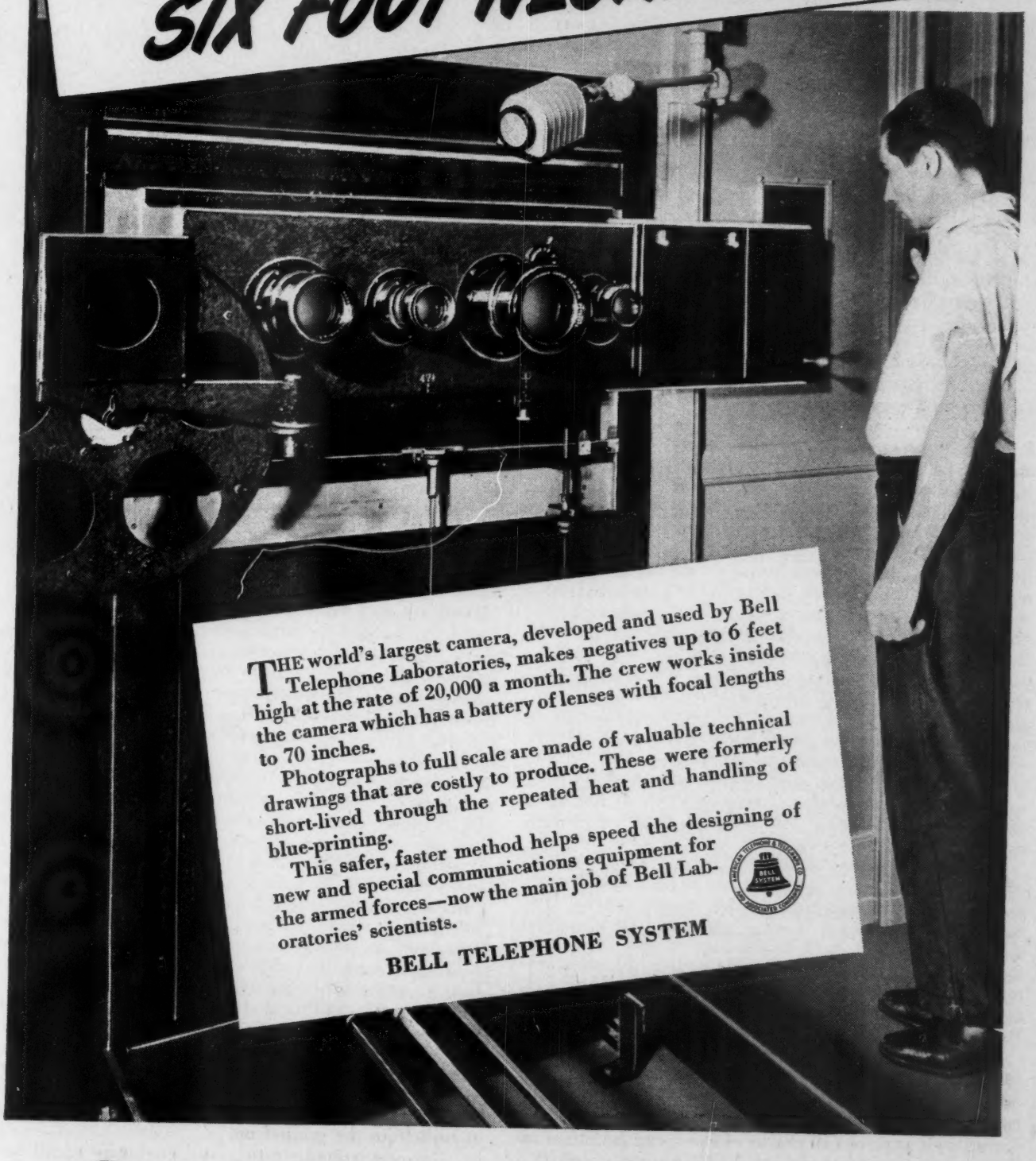
Even cursory examination of the present trend of the war and war strategy can be made to indicate some of the more obvious calls to duty which the postwar engineer will have to answer.

It cannot be denied that in destruction of production facilities Germany and Central Europe have suffered the most. The Allied Air commands have said that the purpose of their bombing of the Continent has been to completely wipe out all phases of European manufacture which can in any way aid the Nazis in their prosecution of the war, which, in effect, means every major industry. By the inclusiveness of their tactics they have unknowingly (or knowingly) helped Tech men of every course to future jobs. For example, some of the most recent raids have been in part the morale-influencing type, directed at centers of population. Under this category has fallen the near-destruction of Berlin and the complete destruction of Hamburg, Cologne, Essen, and Dusseldorf. Reconstructing these cities, together with rebuilding the Molne and Eder dams and the drainage of those parts of the Saar basin flooded by this operation, rebuilding power plants, and the military and civil traffic arteries such as the railway center at Cologne, will be a job for as many civil engineers as are interested. Mechanical engineers will have to rebuild, refit, and man the many automotive and mechanically-based plants, such as the great Renault motor works outside of Paris destroyed in one of the United States Army Air Force raids over Europe, the Ball-bearing plant at Schweinfurt, the Focke-Wulfe plant at Warnemünde, and the Messerschmitt factory at Marienburg which was obliterated by the U.S.A.A.F.

But not all the opportunities opened by the Allied Air Forces have been for the mechanical and civil engineer and architect, although they will carry on a large part of the postwar reconstruction which will be made. Mining and geological engineers will be needed to refind and renovate the oil fields laid to waste in Burma and Rumania and the bombed-out coal, iron, and mineral mines in Germany and Austria. Chemical engineers will play an exceptionally big part in the postwar program. Since German chemical industries, especially those producing synthetic materials, have contributed greatly to the war effort, they have consequently been hit hard by raids. Plants like the aluminum plant at Herroya, Norway which the Germans rushed to completion after Norway's capitulation and which produced most of Germany's aluminum, the synthetic rubber plant at Hüls, the Continental Gummiwerke factory at Hanover, and I. G. Farbindustrie's chemical plants at Wuppertal will have to be rebuilt from the ground up.

Business administrators and engineers of all sorts will be needed for this task. America and Great Britain will be the victorious countries and it will be we who furnish the men. It will truly be a Tech man's paradise. Engineers, the whole world is ahead of you! Prepare to receive it.

# "CANDID" CAMERA SHOOTS SIX FOOT NEGATIVES!



THE world's largest camera, developed and used by Bell Telephone Laboratories, makes negatives up to 6 feet high at the rate of 20,000 a month. The crew works inside the camera which has a battery of lenses with focal lengths to 70 inches.

Photographs to full scale are made of valuable technical drawings that are costly to produce. These were formerly short-lived through the repeated heat and handling of blue-printing.

This safer, faster method helps speed the designing of new and special communications equipment for the armed forces—now the main job of Bell Laboratories' scientists.

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# ALUMNUS OF THE MONTH

## STUART CHASE, '10
### Writer, Lecturer, Economist

*Picture courtesy The Twentieth Century Fund*

***Stuart Chase, Economist; author "Coals for America," "The Road We Are Traveling," "Where's the Money Coming From?," etc.***

"Plato once called for philosopher kings. Today the greatest need in all the bewildered world is for philosopher engineers.* This mean between the theorist and scientist, so sought after in the M. I. T. curriculum, can scarcely be illustrated by a better example than the writer of the above passage, Stuart Chase.

Born March 8, 1888, in Somersworth, N. H., his father (Harvey S. Chase, M. I. T., '83) wanted Stuart to enter his famous Boston firm of accountants. Towards this end Stuart was sent to the Massachusetts Institute of Technology where he entered the class of 1910. He was supposed to learn how to study at Tech. Here he was indoctrinated with a sense of the engineering approach to human problems, an attribute which was to follow him through life and on into his writing career, where it can be evidenced in his erudite and all-inclusive books on economic problems.

Stuart Chase did enter his father's firm of accountants, after having graduated *cum laude* from Harvard. In the last war he served both on the United States Food Administration and on the Federal Trade Commission. After the war he started practicing accounting with the Technical Alliance, the Labor Bureau, Inc., and other concerns, where he continued until 1932. Soon after he had left his father's firm he found that the profit and loss of business concerns interested him less and less and general social problems more and more. His father had sent him to M. I. T. to learn how to think, which was perhaps a great mistake, for he not only thought himself out of accounting, but thought himself into a career of writing. Not that a career of writing was a mistake. His engineering education, his business education, his work with the government, and his association with such organizations as the Technical Alliance and Labor Bureau (the latter of which furnished research, accounting, and other professional services to labor unions and coöperatives) were bound to produce something unusual in the way of a writer. And truly this brilliant author did distinguish himself very shortly.

In 1925 he published his first book, "The Tragedy of Waste." However, it was not until 1927 that one of his works really took hold of the literary world. His book, "Your Money's Worth," published then in collaboration with F. J. Schlink, started the consumer movement which gave rise to such public-minded institutions as Consumers Research. Such a stimulus as this originated such consumer-aimed measures as the Pure Food and Drug Act.

From this date on he devoted more and more time to writing and less to accounting and consulting work. His books took on a dominant theme: the effects of science and technology on human living and the application of scientific knowledge to human problems. They keep this idea in mind throughout, and are aimed at a betterment of the human race in all its states.

For one writer, Chase's books have had more influence, both direct and indirect, upon American thought than most all of the contemporary American authors. His book "Mexico, A Study of Two Americas," published in 1931, predicted to an amazing extent and preceded almost directly the heavy influx of tourists into that country which began in the early 30's. This was followed by "A New Deal," which came out in 1932 during the election. It was Mr. Chase's title that appeared first, not the Administration's. Many of the Administration's policies were foreshadowed by this opinion-shaping book. Again, his "Rich Land, Poor Land," published in 1936, was one of the first of the more comprehensive books on soil conservation and scientific farming techniques. Perhaps it was just a coincidence that his book came out just before the recent trend to more scientific farming and that away from wasteful agricultural policies. Besides the above books he has written "Men and Machines," 1929; "The Economy of Abundance," 1934; and "Government in Business," 1935. "The Tyranny of Words," published in 1936, aroused more interest in the science of semantics than any other book had for nearly a decade.

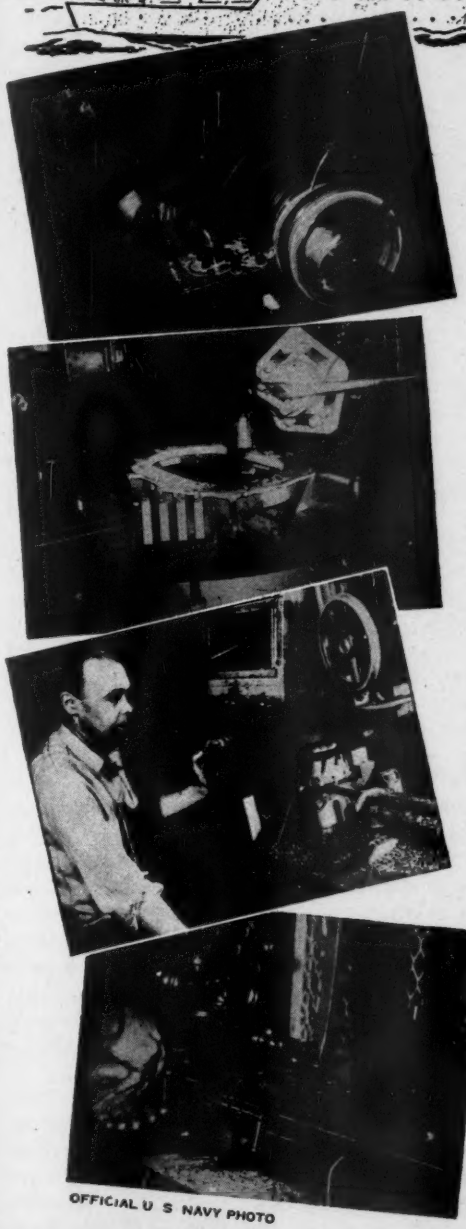
His activities are not limited only to writing. From time to time Mr. Chase has acted as consultant for the Tennessee Valley Authority, Securities and Exchange Commission, Farm Security Administration and the National Resources Planning Board, but he has had no permanent connection with the government since his work for the Federal Trade Commission in 1920.

Engineers who have an open mind toward social questions enjoy Stuart Chase's books. He is a good publicist for their achievements, from TVA dams to industrial relations. But he is no uncritical advocate, and he hands ovo ter them a great responsibility. "Mr. Engineer," he once wrote, "you have played the shrinking violet long enough. You have remade Western civilization, and created at the same time certain malignant evils . . . statesmen, philosophers, generals, poets, may lead self-supporting communities, but only engineers may lead a great, interlocked economic structure."*

* Taken from the *Technology Review*.

# CUTTING THE STEELS OF WAR

## FOR THE Fastest Naval Production in History



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★

***In Industry!*** Typical of the way carbides are helping to speed production of hundreds of parts in industry for naval use is this job of machining cast steel pinion bearings for main drives of destroyers. Cutting at 220 feet per minute, Carboloy tools reduce machining time at least 25%.

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***In Navy Yards!*** In the Navy Yards, too, carbide tools are a vital factor in helping speed production. At Portsmouth Navy Yard, for example, Carboloy tools machine cast steel frames for watertight doors on submarines at speeds 100% faster than before. For this intermittent cutting job, Carboloy grade 78-C tools cut at 150-175 F.P.M., .032" feed, with varying depth of cut up to ⅛".

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***In Naval Ordnance Plants!*** Here again carbide tools have a job to do—and are doing it! Typical is the milling of steel breech casing at a midwestern U. S. Naval Ordnance Plant. Carboloy mills—operating at 650 S.F.P.M., 7½" table travel—eliminate one milling machine and two grinders through faster operation and better finish obtained.

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***On the High Seas!*** When repairs are needed far from port—the Navy is prepared! "Floating" machine shops with modern, efficient equipment—including carbide tools—are a standard part of large Naval vessels.

IN U. S. Navy Yards, in Naval Ordnance plants, aboard naval vessels, and in all important plants of suppliers to our navy, you'll find carbide tools helping to speed up schedules—turning out the steels of war!

The ability of carbide tools to machine at high speeds, produce an unusually high quality of finish, reduce machine downtime, and cut heretofore non-machinable alloys, has been put to extremely good advantage by those charged with the responsibility for the greatest naval production in history.

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Every facility of Carboloy Company has been made available to the U. S. Navy in an all-out program of cooperation. Carboloy representatives from coast to coast are on call whenever needed; Carboloy Training Films are at work helping speed naval training activities in the field; and the Carboloy Training Course at Detroit has trained, and is continuing to train, key navy men responsible for carbide tool use in naval production.

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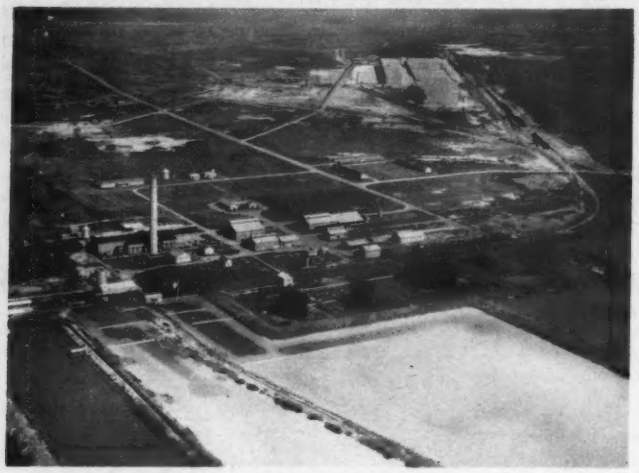
## SULPHUR AND WAR

(*Continued from page 147*)

scale before painting. Its hull was probably painted with anti-fouling paint containing copper sulphate and sulphur, toxic to marine growths. The shiny metal trim of the ship was plated in a bath containing sulphates and sulphonates as electrolytes and brightening agents. Its storage batteries use sulphuric acid as electrolyte. Of the structural parts of our torpedo plane, the magnesium alloys were cast in an inert atmosphere provided by sulphur dioxide, while waste sulphite liquor was a core binder for the casting mold. The screws and bolts in both plane and ship were probably made of sulphur-bearing steel for rapid machineability, and a "cuttingoil" containing from 2 to 18 per cent added sulphur was used in the high speed machining operation.

The intricate engine transmissions of both ship and plane, such as hypoid gears, are lubricated with oils whose film strength, upon which lubricating life depends, was improved by addition of sulphur mixed with an organic phosphine.

As to the fuels which drive both ship and plane, sulphur (as sulphur dioxide or sulphuric acid) has long been used in production and refining of Diesel oils, lubricating oils, gasoline and countless other petroleum products. Sulphuric acid is used in the alkylation synthesis of the high octane gasoline, that triumph of American engineering which super-powers Navy planes as well as those of the other services. Sulphuric acid also increased the gasoline's tetraethyl lead susceptibility, and was used in producing the bromine to make the tetraethyl lead itself.



*Photograph by Robert Yarnall Rickie*

***Airplane view of Hoskins Mound sulphur mine of Freeport Sulphur Company***

Because sulphuric acid is catalyst or dehydrating agent in many organic syntheses, it is quite likely that the methyl methacrylate plastic nose of our plane owes its existence to use of this acid, or to sulphur dioxide used as catalyst in polymerizing styrene with methacrylic acid. The phenol molded plastic parts aboard ship and plane — such as handles and insulators — are also made with the aid of sulphuric acid.

On both ship and plane, the rubber — for gasoline lines, connections, insulations and shock absorbers, de-icers, life rafts and gas tanks — whether it be natural or synthetic — must have its sulphur to give it toughness. If it is synthetic rubber, sulphur has entered at least three times in the flowsheet of its manufacture: (1) as sulphuric acid in forming and purifying the raw materials; (2) as sulphuric acid in coagulating latex into crude; and (3) finally as sulphur in compounding Buna S for tires and all other final products. For places where resistance to oil and sunlight are desirable, as on board a carrier, there is Thiokol, another valuable synthetic rubber containing 80 per cent sulphur.

Wherever rayon of the viscose type appears, whether in parachute harness, powder bags, cellophane wrappings or in a multitude of wool-like staple fibre articles, sulphur has appeared at least three times: first, to prepare the cellulose by the sulphite paper process; second, as carbon bisulphide to make the viscose "crumb"; and third, as acid in the coagulating bath.

The torpedoes carried by our plane on its purposeful missions are charged with TNT or other high explosive, the part sulphur plays in that manufacture having already been described. Tracer flares of strontium and barium peroxide and drift indicators made of titanium dioxide have depended upon sulphur at one or more steps in their manufacture. And the results of the mission will be recorded in the plane's cameras, on celluloid film which was made with the aid of sulphuric acid.

Coming down to the equipment of the human element on ship and plane, even the uniform woolens are dyed with navy sulphone dyes and the presence of sulphuric acid in the dye bath increases the affinity of the wool for the dye. The leather in the pilot's coat has been dehaired, softened and tanned with sulphur chemicals, and the mercerized cotton in the crew's underwear was treated with a brief immersion in 65 per cent sulphuric acid to improve yarn lustre and strength. Washing the clothes in "hard" sea water is facilitated by sulphonated soaps. The smoked glasses the pilot wears may have been made with potassium bisulphide or sulphur.

The maps which guide both ship and plane were copied with parchmentized paper cleared with sulphuric acid on one side, while the clarity of the maps and their strength to withstand much handling, are due to the bisulphite cooking of wood pulp into high strength papers. For reading in the dark they are printed with barium or zinc sulphide phosphorescent inks.

Fresh foods appear on our carrier ship's table, though far from port, thanks to modern refrigeration methods in which sulphur dioxide, as gas refrigerant, has played an important role; and the same material preserves the Vitamin C of dried fruits, staples in the diet of modern seamen on long cruises, in contrast to the "limeys" (lime juice drinkers) of other days. Sulphur also can help to keep the drinking water supply pure. Should the crew be wounded, the wonder-working "sulpha" drugs of this war, in whose complex molecule sulphur is part of a radical toxic to gangrene bacteria, will be summoned at once to serve.

The tobacco in the cigarettes smoked by our crew has been grown with the aid of potassium sulphate fertilizer, the paper processed by the bisulphite method. Even the match contains a little sulphur, although not as much as when it was described in Pliny's "Historia Naturalis" (8.51,38) in about the year 70 A.D. Even the music which enlivens the crew's leisure moments comes from a record produced from a master of montan wax and sulphur.

So, throughout the varied and intricate processes which have been used to turn out the torpedo plane and crew, with more and better equipment than any fighting force in the world's history, the golden thread of sulphur can be traced.

# CUSHIONING *Flagships* FOR EASY LANDINGS

GLIDING in to an easy landing as a climax to a safe, comfortable flight is the result of attention to many details. That "cushioned landing," for example, is prepared before the flight by a serviceman as pictured above. He is giving the oleo struts their exact amount of "air cushion" — and an Airco gas regulator does the job accurately. The same method is used for controlling the air pressure to balance the hydraulic system which operates landing flap brakes and retractable landing gear—and Airco nitrogen is the gas widely used for this purpose.

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## WHAT YOU EAT IS OUR BUSINESS

(*Continued from page 149*)

groups, examined carefully for nutritional deficiencies by special techniques. After examination, one group, the control group, was allowed to continue its work as usual; the other groups, the test groups, are being given several different vitamin supplements. After a period of six months all of the workers were reëxamined and will again be examined at the end of a year. The results of these examinations will be studied carefully to determine the effect, if any, the vitamin supplements had on the health and production of these employees. This type of applied nutrition is so new that no results have yet been made public, but nutritionists are looking expectantly toward the near future for information which will guide them in the formulation of better methods for the in-plant nutrition of industrial workers.

Before the war, our laboratories began a study of elementary school lunches in an effort to develop an inexpensive food which would provide a major portion of a child's daily nutritional requirements. A simple formula, containing as its base peanut and soybean protein, vitamins and minerals, satisfied the conditions under which it was used, and proved to be acceptable in all respects in a demonstration feeding in Michigan. This test, sponsored by the Kellogg Foundation, although of only three months' duration, showed definitely that the nutritional status of school children could be improved by an enriched food supplement of this type.

The application of supplementary feeding in this manner is not limited to the feeding of school children, but may be used wherever inexpensive large-scale feeding is necessary or advisable. The Russian government was impressed by the utility of this prepared food and is now receiving, together with other Lend-Lease material, large shipments for the feeding of its people, It is quite possible that this food, or something similar. may be the basis for large-scale feeding among destitute populations in war-torn areas as soon as they are occupied by Allied Armies. This would be an excellent example of applied nutrition.

The theory of population nutrition as applied in the United States, which is endowed by nature with an exceptional variety of healthful foods, does not apply in all respects to other countries. We know that feeding habits are the heritage of the ages. We who are accustomed to our fresh vegetables, orange juice, meat, milk, eggs, bread and butter could hardly hope to exist for long on the fish, bean sprouts and soybeans of China, or on the corn tortillas, beans, fruits and pulque of Mexico. We are talking now about the routine diet of Mr. Average Citizen in these countries. We can hardly hope ever to educate the Chinese or the Mexican to live in his country as we live in ours. Their countries, or countries in other parts of the world, cannot employ the same type of agricultural economy that is so familiar to us. Nevertheless, by our standards the average person in many parts of the world is malnourished and our immediate desire requires that we do something to ameliorate conditions. How best may we do this? Let us study the situation in Mexico, for reasons which will be obvious shortly.

In Mexico we find a people subsisting, as we see it, at a low nutritional level, a level which is worse, if anything, than that of their forefathers. This is due primarily to a lack of arable land and secondarily to a depletion of soil nutrients brought about by continued cultivation without concurrent replenishment. The crops are limited in general to corn, beans and, to some extent, cereal grains and peppers. These together with native fruits and vegetables comprise the national dietary. There is no milk, meat, eggs, enriched bread or butter. Nevertheless, a nutritional survey among rural residents conducted by the Rockefeller Foundation showed that deficiencies were the exception and not the rule. In spite of this we do not believe that the people are as well fed as they might be, and we want to set

(*Continued on page 168*)

***Miss Aguilar, Dr. Cravioto, Dr. Tapia, and Dr. Segura confer over a problem***

# Massachusetts Institute of Technology
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The duration of each of the above undergraduate Courses is four academic years, with the exception of Architecture, Physical Biology, and the co-operative Courses in Electrical Engineering and in Mechanical Engineering, which extend over a period of five years, and City Planning Practice which covers a period of six years. In addition to the Bachelor's degree, the above five and six year Courses, with the exception of Architecture, lead also to the Master's degree.

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For information about admission, communicate with the Director of Admissions.

**The Catalogue for the academic year will be sent free on request.**

## WHAT YOU EAT IS OUR BUSINESS

(*Continued from page 166*)

up a program by which the nutritional level can be raised. Under the auspices of the Kellogg Foundation, and with the collaboration of the Mexican government and the Pan American Sanitary Bureau, our laboratories have been given such an opportunity.

Since we do not have the same wealth of information concerning the vitamin content and composition of Mexican foods and nutritional status of Mexican people that we have with respect to our own foods and people, we must start at the beginning. To this end we have at the present time here at the Institute five representatives of the Mexican government. Dr. Rene Oscar Cravioto Barrera and Miss Estela Aguilar Gonzalez are chemists extending their knowledge of methods by which foods are analyzed for their gross composition and their vitamin and mineral content. The first complete analyses of Mexican foods are being made on samples sent here by their government. Since it is possible to complete the work on only a small number of foods during their brief stay, they will upon their return to Mexico continue the study in a newly organized laboratory under Dr. Francisco de P. Miranda, head of the National Institute of Nutrition.

The studies have progressed to the extent that we have some indication why nature may be considered the prime nutritionist and why extensive nutritional deficiencies are, so far as our present meager knowledge is concerned, non-existent. For example, the amounts of vitamin C, the anti-scurvy vitamin, vitamin A, the anti-infection vitamin, iron and calcium in a very common plant called malva, which is eaten in large quantities by the poor Indians in the Mesquital Valley, are adequate for good nutrition with respect to these factors. One fruit which is eaten extensively contains sufficient vitamin C nearly to satisfy known requirements. We feel, therefore, that we shall not find it necessary for the Mexican people to grow oranges, lemons and tomatoes as their source of vitamin C. Without doubt other well known but unstudied foods make their contribution to nutritional sufficiency in the Mexican dietary.

All proteins are not as adequate nutritionally as are the proteins of meat, eggs and dairy products. Since these are almost entirely lacking in Mexican dietaries, it is necessary to determine which of the Mexican foods provide adequate proteins. During his stay in this country, Dr. Marco Aurelio Tapia Ruiz will learn methods of testing the nutritional value of proteins by animal experimentation. Although he will spend most of his time here at M. I. T., Dr. Tapia will also visit other laboratories where similar experimentation is being carried out. We feel sure that future work will reveal the protein component of the average Mexican dietary is nutritionally adequate.

This study of food composition will provide data upon which the second phase of our coöperative nutrition program is based. Early this coming spring a demonstration feeding, similar to the Michigan study, will be started in Mexico City. Fifteen hundred Mexican school children are to be examined and graded according to their nutritional status. They will be divided into two groups: the one, a control group receiving no school lunch, and the other, a test group receiving a lunch of Mexican foods having a known nutritive value. At the end of six months' period all of the children will be reëxamined and the results compared with those obtained at the beginning of the study. It is hoped that this experiment will prove the value of scientifically planned mass feeding, and lead to the establishment of similar programs throughout the world.

We have visiting us Dr. Rafael Segura Millan and Dr. Maria Guadalupe Eguiluz, also of the National Institute of Nutrition, who will supervise the nutritional survey and the school lunch program. They are now here to extend and crystallize their knowledge of methods for nutritional appraisal, and to prepare tentative plans for the feeding demonstration. In Mexico City they will be assisted by three members of our staff who, in addition to their regular duties, will strive to keep alive the spirit of international coöperation and foster the union of scientific strength already initiated by this program.

The science of applied nutrition, the application of nutritional theory to provide good health and efficient living for all classes and races of people in all walks of life is still so much in its infancy that the work to be done outweighs the results achieved. We feel, however, benefits still to be derived will enable future generations to enjoy more fully the better world that other sciences are building for us.

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## GUAYULE GROWS UP

(*Continued from page 153*)

Since the government assumed the guayule projects two years ago, many steps have been taken to improve the method of extraction. New methods for removing the resins from the rubber, elimination of mechanical crushing of the shrub, increasing the percentage of rubber recovered, and cutting costs in the milling operation, are a few of the problems that are being worked on. There is no doubt that solutions will be found in the near future.

The widespread use of guayule in a peace-time world is somewhat doubtful. The present government production program of guayule was conceived purely as a war effort, aimed to relieve the critical rubber situation. When the war is over, government guayule production will cease, under the pressure of the rubber companies of the world which will wish to return to the more profitable Hevea. Even synthetic rubber will not prevent this return to Hevea as the world's source of rubber.

A great deal has been done in the compounding of guayule with other materials in the manufacture of the finished rubber product. Outstanding among these research men have been Prof. E. A. Hauser and D. S. LeBeau of the Chemical Engineering Department of M. I. T. Unfortunately, these discoveries are too technical to be discussed in an article of this type.

The emergency development and successful exploitation of this natural resource by our scientists, represents another nail in the coffin of Naziism, even though it is made from rubber.

*Cover picture*
*Courtesy Climax Molybdenum Company*

*Title page picture*
*Courtesy Freeport Sulphur Company*

*Frontispiece*
*Courtesy Climax Molybdenum Company*
*Robert Yarnall Richie Photos*

## *As one student to another*

Because we know so well what changes have taken place on your campus and how they must be affecting your view of things, we would like to remind you of something.

Alcoa Aluminum probably means to you now just a whale of a lot of aluminum that is going into war tools.

But Alcoa, the company, is people.

And we have a long-time goal—a very human, peacetime goal we are saving in the hope of sharing with you. We would like you to think of us as Imagineers in aluminum, creators of employment and higher standards of living.

Alcoa is, first of all, a great collection of engineering knowledge based on experience that goes back to the birth of aluminum as a commercially available metal.

Then, it is imagination. It is the vision that sees aluminum, not as just another metal to sell but as a means of eliminating dead weight, or corrosion; as a means of reducing maintenance costs or increasing output.

The full significance of Alcoa can be summed up as experience in the application of aluminum to make more things available to more people. It's what we consider the only means of solving the perennial employment problem.

It requires constant inquiry. Constant study. Constant co-operation with every field of human effort that uses metal.

The results are as practical a way of bringing about a better world as any yet devised.

We hope, when we both return to the job of rebuilding the world, some of you will choose to do it with aluminum. That will mean, of course, with *Alcoa.*

*A PARENTHETICAL ASIDE: FROM THE AUTOBIOGRAPHY OF*

ALCOA ALUMINUM

REG. U. S. PAT. OFF.

• This message is printed by Aluminum Company of America to help people to understand *what we do* and *what sort of men* make aluminum grow in usefulness.

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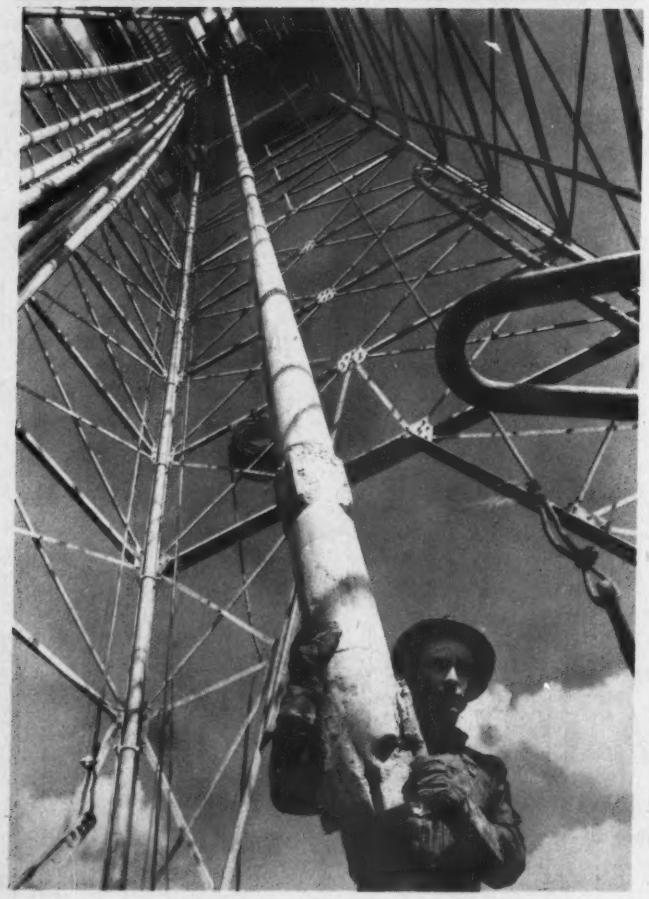


## MOLY, WORKHORSE OF THE OIL FIELDS

(*Continued from page 159*)

ous strains at high temperatures without permanent deformation, imparting a high creep strength to the alloy. It offers high hardness and impact strength, and also intensifies the effect of other elements added for corrosion resistance, in addition to being somewhat corrosion resistant itself. The addition of molybdenum provides more uniform hardness and greater depth hardening without the brittleness that usually accompanies such an operation.

Also valuable is the ease with which many molybdenum steels can be worked. Molybdenum steels are easily machined, reducing the wear and tear on cutting edges. Furthermore, molybdenum is one of the only commercial alloying elements in use today that do not interfere with or adversely affect welding. These factors naturally improve production uniformity and reduce the cost of producing equipment.

Chromium-molybdenum steels are probably the

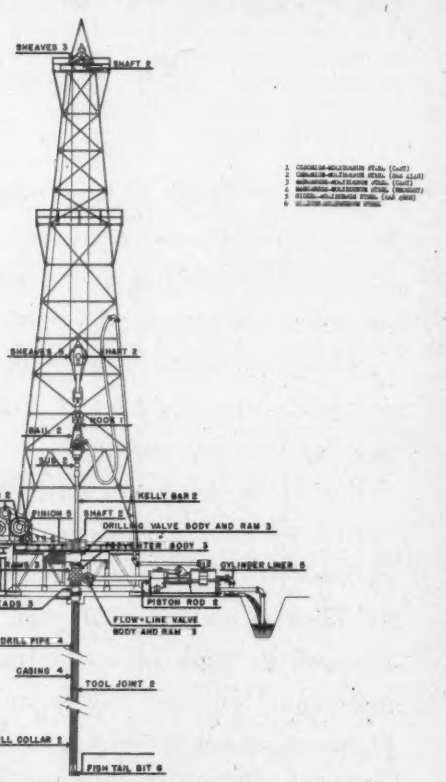


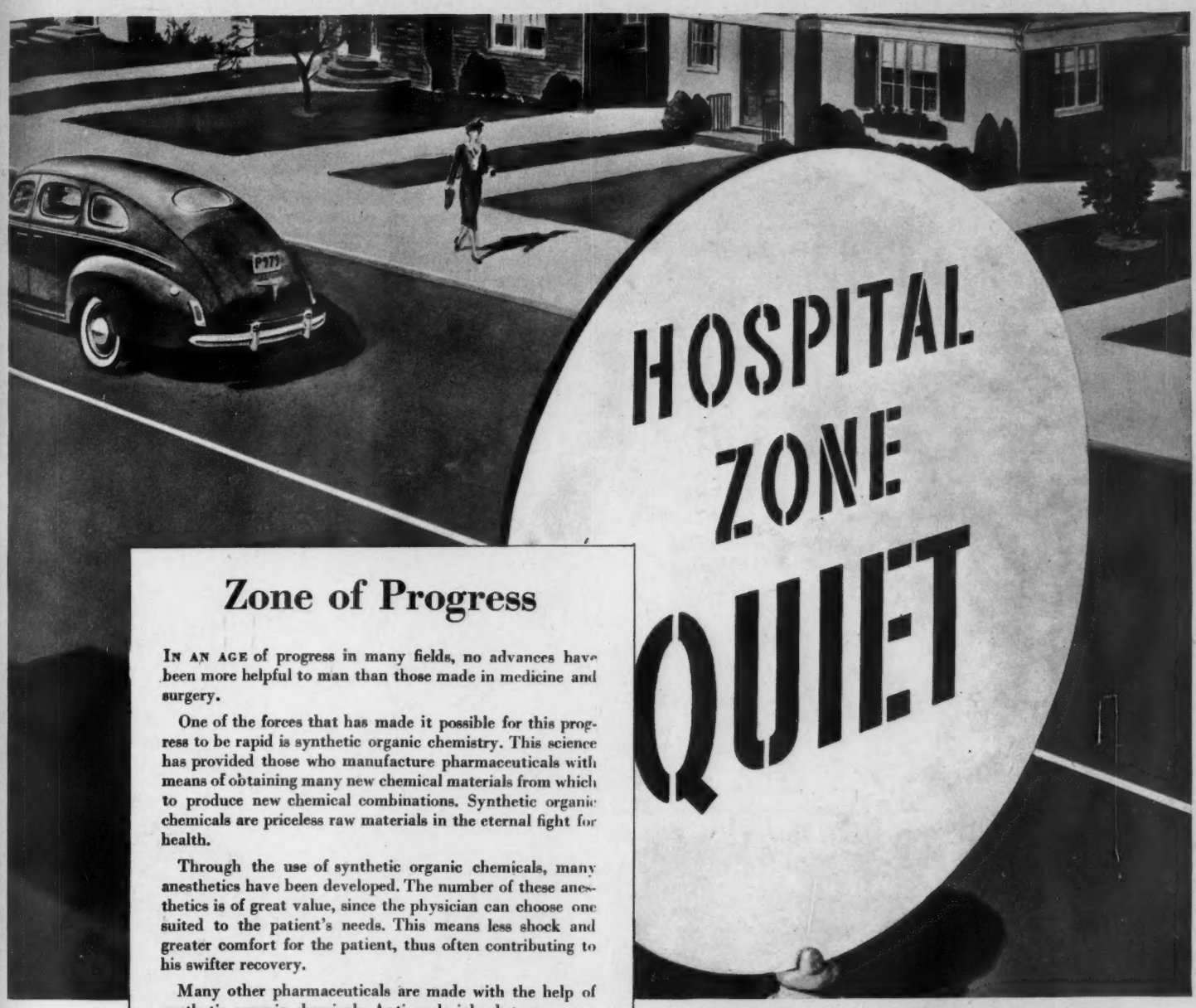

***Figure 1. Detailed drawing of a rotary drilling rig used for deep drilling. Parts labeled are made of molybdenum steels.***

most used, and therefore the most familiar of all the molybdenum steels employed in oil production. One reason for this is their versatility, in that they may be treated to meet widely varying physical requirements. They have a high impact strength at any given tensile strength, and they can be treated to relatively high hardness without sacrificing ductility. This group of steels is suitable to all sorts of applications subject to heavy fatigue, torsion, or impact loads, or to abrasion, and erosion. They are practically free from temper brittleness.

Nickel-molybdenum steels are among the highest grade steels which were used in oil production equip-

(*Continued on page 172*)

***Drilling string with fish-tail bit attached***




## Zone of Progress

IN AN AGE of progress in many fields, no advances have been more helpful to man than those made in medicine and surgery.

One of the forces that has made it possible for this progress to be rapid is synthetic organic chemistry. This science has provided those who manufacture pharmaceuticals with means of obtaining many new chemical materials from which to produce new chemical combinations. Synthetic organic chemicals are priceless raw materials in the eternal fight for health.

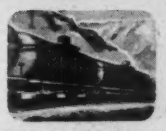
Through the use of synthetic organic chemicals, many anesthetics have been developed. The number of these anesthetics is of great value, since the physician can choose one suited to the patient's needs. This means less shock and greater comfort for the patient, thus often contributing to his swifter recovery.

Many other pharmaceuticals are made with the help of synthetic organic chemicals. Anti-malarial substances, synthetic adrenalin, man-made vitamins, anti-pyretics (to cut down fever), many kinds of sedatives, vehicles in which drugs are administered, and solvents used in extracting drugs from natural sources are some of the medicinal aids made possible by these chemicals.

CARBIDE AND CARBON CHEMICALS CORPORATION, the Unit of UCC which pioneered in the field of synthetic organic chemistry, has made more than 160 synthetic organic chemicals available in commercial quantities. Many of these chemicals are important in various ways in the pharmaceutical industry.

*Pharmaceutical manufacturers, and research and technical men in chemical and allied industries, are invited to send for a copy of the 100-page booklet P-2, "Synthetic Organic Chemicals," which technically describes the properties and some of the uses of these chemicals in pharmaceutical and other fields.*

***BUY UNITED STATES WAR BONDS AND STAMPS***



**SAVINGS FOR YOU!** Synthetic chemicals in tank-car quantities serve as solvents and raw materials throughout industry to make more and better things at less cost to you.

**COLD-PROOF!** Coolant for liquid-cooled aircraft engines and base for anti-freeze in military cars and trucks is ethylene glycol, an important synthetic chemical.

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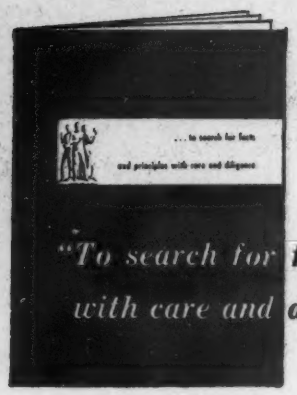


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## MOLY, WORKHORSE OF THE OIL FIELDS

(*Continued from page 170*)

ment before the war. They were used where strict physical requirements are necessary, such as in hard rock bit cutters. Nickel-chromium-molybdenum steels are used for such parts as kelly bars, drill collars, and heavy shafting, where advantage can be taken of their excellent properties in heavy sections.

The outstanding properties of silicon-molybdenum steels, from the oil production standpoint, are their response to rough and ready heat treatment, high impact strengths at high hardnesses, and excellent torsional strength. They are also easily worked on in the field, and are therefore used extensively for fish-tail bits, rock bit bearings, chisels, and reamer bodies.

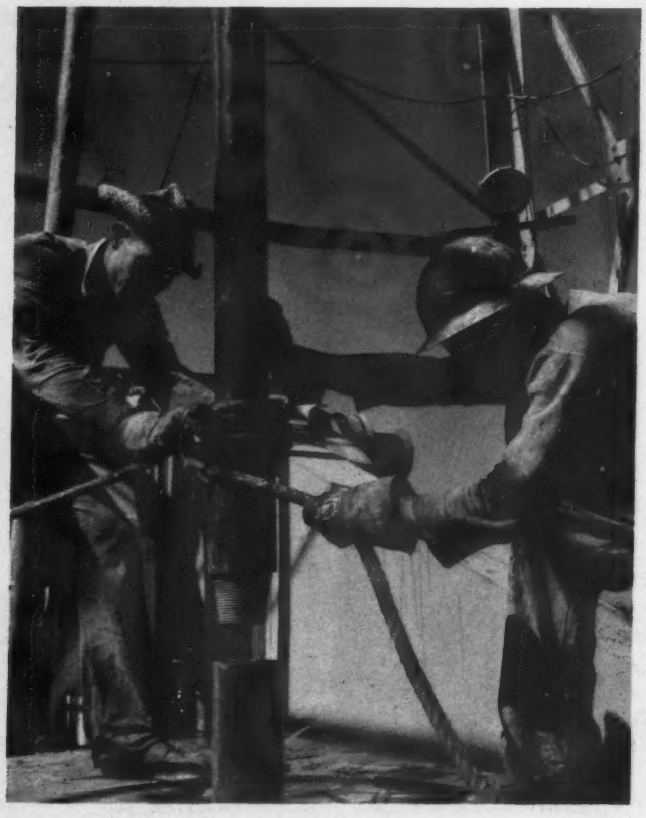
The principal use of cast steel in oil production equipment is in the manufacture of parts that are either too bulky or too complicated to be economically

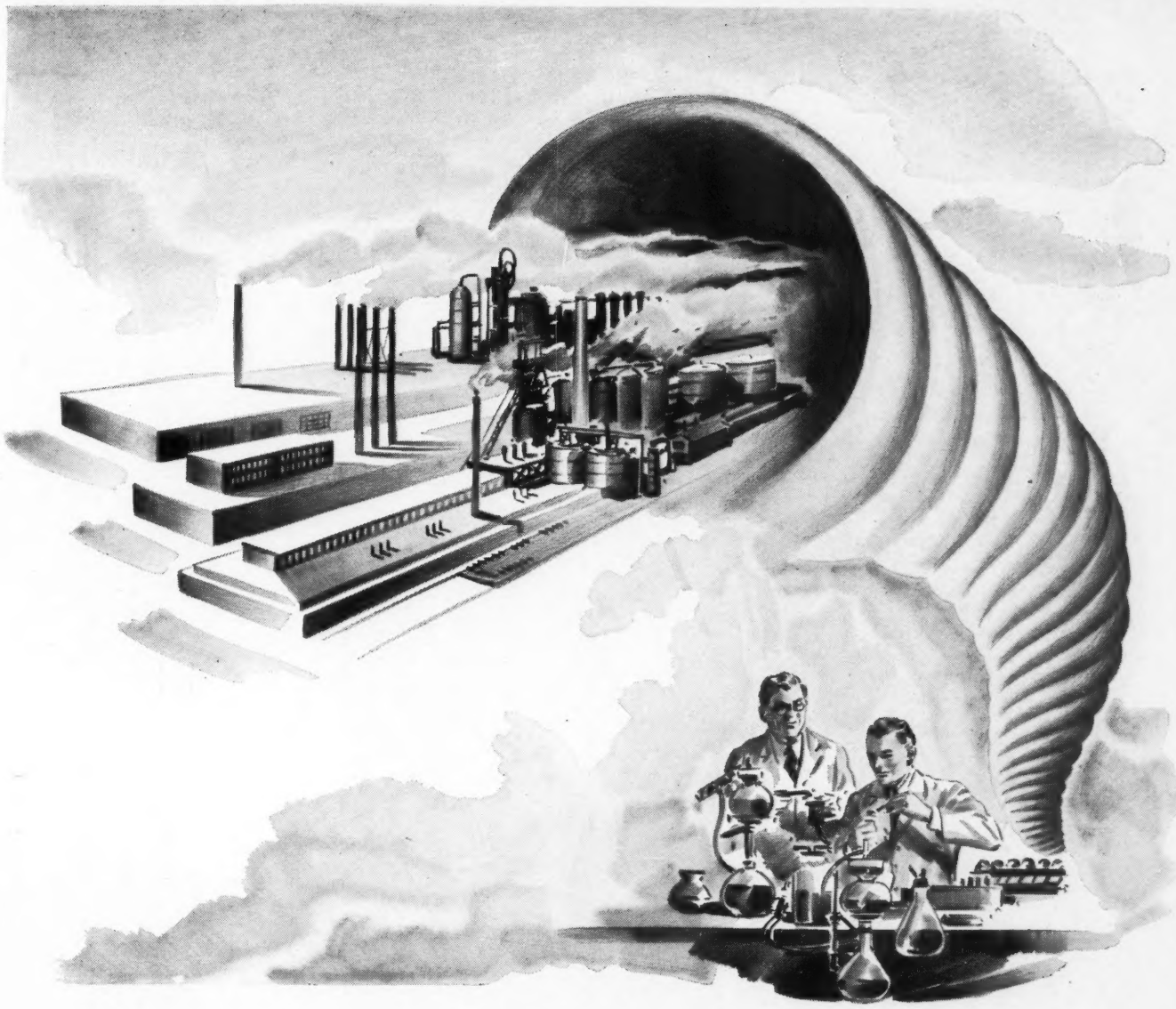
*Gun perforator. This device is lowered down the well and shoots special bullets which pierce the cement casing and allow the oil to flow into the well*

fabricated from wrought steel. There are a number of cast steel parts particularly common to oil production equipment that give a good idea of the general field for cast steel. Among them are casing hooks, drag bits, rock bit bodies, valves, slush pump parts, casing heads, gun perforator bodies, and blowout preventer bodies. There is a corresponding type of molybdenum cast steel for almost every type of molybdenum wrought steel, and the properties and service capacities are very similar.

The future of molybdenum is broadening on all horizons. It is even now being used as a catalyst in the refining of high octane gasolene, and it has entered the chemical field in many other ways as well. It is used in the elements of many electronic tubes, and finds many widely varying applications in other industries. The world consumption of this metal has increased 30,000 per cent in the last three decades, so it is not hard to guess that this upstart among the metals in industry has an amazing future.

*Stabbing a tool joint. Rope shown spins from cathead Tool joints are often made of chromium-molybdenum steel*





## Chemistry and Industrial Evolution

Industry has been free to use its own resources for new developments—to engage in research—to examine, reject or adopt new ideas. Commonplace necessities which do not lend themselves to fundamental change are improved by new production methods and the use of new matetrials. This freedom of action has kept industry from becoming static.

Industrial chemistry is more susceptible to this evolutionary process than perhaps any other enterprise. By developing new materials, test tubes generate fresh energy for the advancement of industry at large. From these materials, new products often evolve. There is no stronger testimony to the place of chemistry in this process than the more than 500 products produced by Dow—chemicals indispensable to Industry and Victory.

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# GE Campus News

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD

## TEST FLIGHT

TINY electric strain gages on the wing answer one of many plane-design problems. No bigger than a penny matchbox, these gages give on-the-spot readings that tell the engineers where to strengthen, where to lighten many of the plane members. Frequently, the readings on dials lead to a more efficient design technique and a desirable reduction in weight.

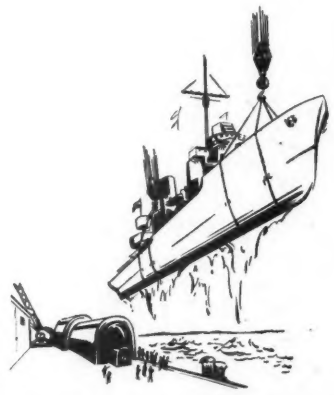
Armed with the General Electric strain gage, engineers can get the answer to ship, plane, and gun design problems quicker than ever before.

How deep can a submarine submerge? How big a firing charge will a gun stand? How great a load will a roll-bending machine take? The strain gage knows the answers.

## BUBBLE-WELDING

"BUBBLE, bubble" takes the "toil and trouble" out of welding magnesium, the strong, lightweight metal derived—among other sources—from sea water. Magnesium is so light that a grand piano made from it could be lifted by one man . . . so strong that its use in airplane construction is desirable.

General Electric has developed a technique for welding this metal inside a "bubble," an invisible one of non-inflammable helium gas surrounding the welding arc. By means of the bubble, nitrogen and oxygen—which would otherwise combine with the magnesium—are excluded, and the welding conditions brought under accurate control.



## 200 FEET A MINUTE—UP!

A DESTROYER *could* move that fast, in that direction, if the world's most powerful motor were lifting it.

This giant direct-current motor is one of the youngest in the General Electric family of motors. It was recently completed at the company's Schenectady plant, and has just been shipped to Geneva, Utah. It possesses a maximum of 4,100,000 pound-feet torque, thus developing more turning power than any other motor, either a-c or d-c, ever built.

At Geneva, it will be installed in the DPC plant which is operated by the Geneva Steel Company, and will help roll out steel for Navy ships.

*Hear the General Electric radio programs: "The G-E All-girl Orchestra" Sunday 10 p.m. EWT, NBC—*
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